Szechwan Basin, and the possible basins in Tibet not counted by Meyerhoff. By contrast, most of the large oil deposits of the world were formed and are trapped in a marine environment.

The world's important producing continental deposits of oil yield high-paraffin, medium- to high-gravity, very low sulfur crudes. The crudes from the three largest Chinese oilfields, which account for 80 percent of the national output of crude, conform to the pattern (see Figure 2).

China, despite its relatively backward oil technology, has 13 thermal and 27 b/d[8] output.

The risk inherent in estimating the rate of ultimate recovery of oil in exploitable pools is heightened by China's unusual geology. Maurice J. Terman of the USGS believes that Chinese lacustrine deposits may have as large a volume of hydrocarbons *in situ* as deposits in the Middle East but that perhaps only a small fraction will ever be recovered, because there are so many scattered, unexploitably small concentrations and because much of the hydrocarbons remains in the form of kerogen or oil shale.

Onshore Reserves

The consequential estimates of Chinese onshore liquid oil reserves[9] are set forth in Figure 3. They include the findings of a private study designed to address the potential impact of China on world oil supplies and the preliminary indications from a USGS study underway. There have been many more estimates circulated,[10] but on examination, they turn out to be outdated or to be guesses unsubstantiated by adequate research and study. Peking's announcement in May 1973 that Chinese oil reserves were "third

China
Oil Production Prospects

ER 77-10030U
June 1977

PHOTO CREDITS:

China Pictorial - pages 4, 7, 12, and 23
China Reconstructs - page 13

Summary

China's oil export potential has drawn worldwide attention since the 1973 Arab oil embargo, which coincided with China's first commercial sale of crude oil. Some predictions have been unreasonably high, including one that presents China as a future Saudi Arabia. These predictions assume China has vast oil reserves and the financial and technological means to exploit them.

Actually, not even the Chinese know the size of their reserves. While we have no evidence that China's reserves are on the Middle East scale, we nonetheless believe they are considerable. Working with limited information, experts in academia, oil companies, and the US Geological Survey generally agree that China's onshore oil reserves are comparable with the 39 billion barrels (BB)[1] remaining in the United States. We share this view. Offshore, the latest studies are dampening earlier hopes that the eastern continental shelf might be one of the world's most prolific oil and gas reservoirs. The most optimistic estimates now suggest offshore oil reserves are about the same as those onshore.

Beyond the question of reserves, there are severe financial and technological restraints on increasing Chinese oil production and exports. For 26 years, Peking has force-fed the oil industry with funds and technical manpower. In response, output has grown 20 percent or more annually, much faster than in the rest of industry. Crude output reached about 1.7 million b/d in 1976, comparable with that of Indonesia. Now, however, the rate of growth will certainly decline. The most accessible reserves are being exploited; investment in other industries, especially coal and steel, can no longer be held back to free funds for oil. Moreover, trained manpower is spread thin just to operate the existing industry. Internal conflicts have not allowed the influx of foreign capital and technology needed to rapidly develop offshore reserves.

The estimated reserves of 17-30 BB in the north and northeast–the regions likely to supply the bulk of output in the short run–would be exhausted in 10 years if output were to continue to grow at the 20-percent rate. If the growth rate were to drop as low as 10 percent, expanding domestic demand might not be satisfied. Developing the western and offshore reserves fast enough to support recent growth trends may not be feasible without help from the international oil companies. Some foreign technology has been acquired through selective purchases of US and other advanced equipment, covering the gamut from exploration through tertiary recovery, but not enough to substantially affect output potential in the short run.

On balance, we believe that China will produce 2.4-2.8 million b/d by 1980. Most of this oil will be needed for domestic consumption; exports are likely to be only 200,000-600,000 b/d. Within a decade or so, continuously expanding domestic demand will absorb total capacity unless deposits in the west or offshore are proved and exploited much more rapidly than expected.

Section I presents the limited body of literature on the size, distribution, and characteristics of China's oil reserves and supplements it with the findings of a private study and of USGS geologists.

Section II provides estimates for national production of crude oil in China since the Communist takeover in 1949 and for each of the major oilfields. In Section III each of the major fields is discussed.

Section IV assesses China's potential to expand crude oil production based on the size and location of reserves, human resources, and capital and technology.

CONTENTS

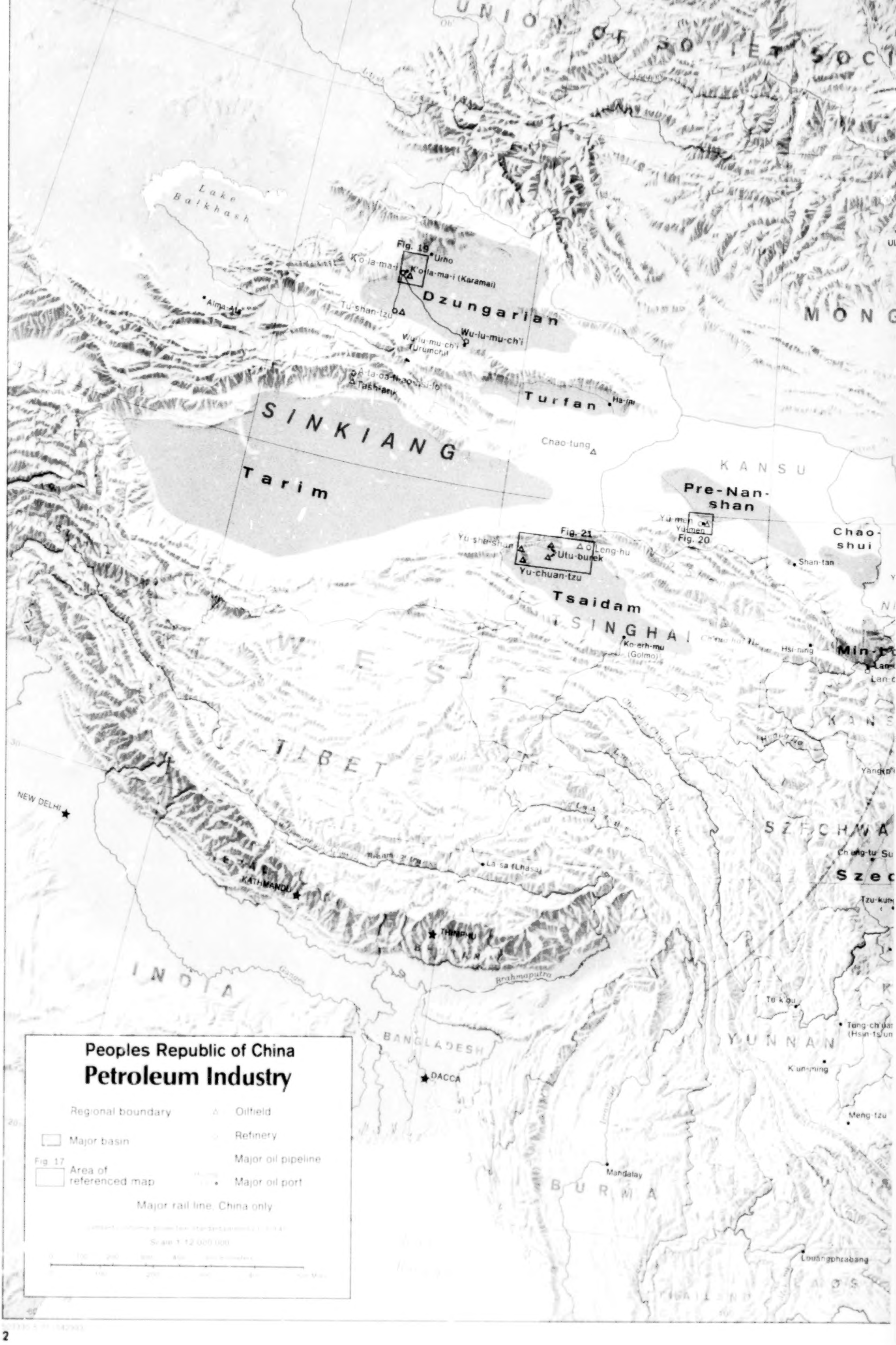
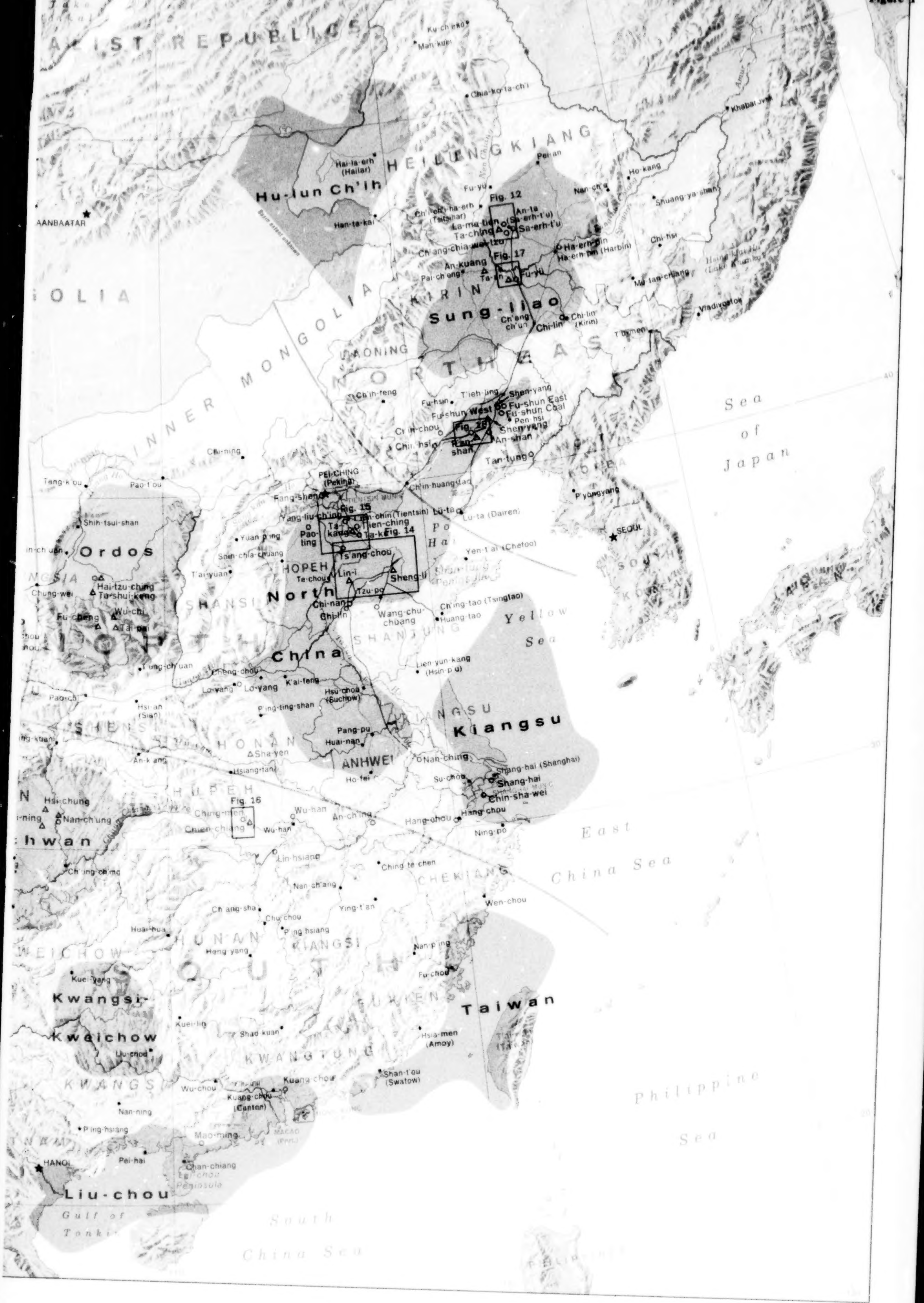

Peoples Republic of China
Petroleum Industry
Regional boundary
Oilfield
Major basin
Refinery
Major oil pipeline
Fig. 17
Area of referenced map
Major oil port
Major rail line, China only
UNION OF SOVIET SOC
MONG
Lake Balkhash
Alma-Ata
Fig. 19
Urho
K'o-la-ma-i
K'o-la-ma-i (Karamai)
Dzungarian
Tu-shan-tzu
Wu-lu-mu-ch'i
Wu-lu-mu-ch'i (Urumchi)
Turfan
Ha-mi
SINKIANG
Tarim
Chao-tung
KANSU
Pre-Nan-shan
Yu-men
Yumen
Fig. 20
Chao-shui
Shan-tan
Fig. 21
Leng-hu
Utu-bulek
Yu-chuan-tzu
Tsaidam
TSINGHAI
Ko-erh-mu (Golmo)
Hsi-ning
WEST
TIBET
NEW DELHI
KATHMANDU
THIMPHU
La-sa (Lhasa)
Brahmaputra
INDIA
BANGLADESH
DACCA
SZECHWA
Ch'eng-tu
YUNNAN
K'un-ming
Meng-tzu
Mandalay
BURMA
Louangphrabang

Figure 1



Hu-lun Ch'ih
HEILUNGKIANG
Hai-la-erh (Hailar)
Han-ta-kai
Fu-yu
Pei-an
Fig. 12
An-ta
Sa-erh-t'u
Ta-ching
Ch'ang-chia-wei-tzu
Fig. 17
An-kuang
Fu-yu
Ha-erh-pin (Harbin)
KIRIN
Sung-liao
Ch'ang-ch'un
Chi-lin (Kirin)
Mu-tan-chiang
Vladivostok
Khabarovsk
Ho-kang
Shuang-ya-shan
Chi-hsi
Chia-ko-ta-chi
Ku-ch'eng
Man-kuei
INNER MONGOLIA
OLIA
LIAONING
NORTHEAST
Ch'ih-feng
Fu-hsin
T'ieh-ling
Shen-yang
Fu-shun West
Fu-shun East
Fu-shun Coal
Pen-hsi
Fig. 20
An-shan
Tan-tung
Chin-chou
Chin-hsi
Sea of Japan
P'yongyang
SEOUL
PEI-CHING (Peking)
Fang-shan
Fig. 15
Yang-liu-ch'ing
T'ien-chin (Tientsin)
Ta-kang
Fig. 14
Pao-ting
Lü-ta
Lü-ta (Dairen)
Ch'in-huang-tao
Yen-t'ai (Chefoo)
Ch'ing-tao (Tsingtao)
Huang-tao
Yellow Sea
Teng-k'ou
Pao-t'ou
Shih-tsui-shan
Ordos
Hai-tzu-ching
Ta-shui-keng
Chung-wei
Wu-chi
Fu-cheng
Chi-ning
Yuan-p'ing
Shih-chia-chuang
T'ai-yuan
HOPEH
Ts'ang-chou
Te-chou
Lin-i
Sheng-li
North
Tzu-po
Chi-nan
SHANSI
Wang-chu-chuang
SHANTUNG
China
Lien-yun-kang (Hsin-p'u)
Cheng-chou
Lo-yang
K'ai-feng
Hsu-chou (Suchow)
P'ing-ting-shan
Hsi-an (Sian)
HONAN
Sha-yen
An-k'ang
Hsiang-fan
Pang-pu
Huai-nan
ANHWEI
KIANGSU
Kiangsu
Nan-ching
Su-chou
Shang-hai (Shanghai)
Shang-hai
Chin-sha-wei
Ho-fei
HUPEH
Fig. 16
Ching-men
Ch'ien-chiang
Wu-han
An-ch'ing
Hang-chou
Ning-po
East China Sea
Hsi-chung
Nan-ch'ung
Ch'ung-ch'ing
Lin-hsiang
Ching-te-chen
Nan-ch'ang
CHEKIANG
Wen-chou
Ch'ang-sha
Chu-chou
Ying-t'an
P'ing-hsiang
HUNAN
KIANGSI
Hang-yang
SOUTH
Nan-p'ing
Fu-chou
FUKIEN
Taiwan
Kuei-yang
Kwangsi-Kweichow
Kuei-lin
Shao-kuan
Liu-chou
KWANGTUNG
Hsia-men (Amoy)
Shan-t'ou (Swatow)
Philippine Sea
Wu-chou
Kuang-chou
Kuang-chou (Canton)
Nan-ning
P'ing-hsiang
Mao-ming
MACAO
HANOI
Pei-hai
Chan-chiang
Liu-chou
Gulf of Tonkin
South China Sea
ULAANBAATAR

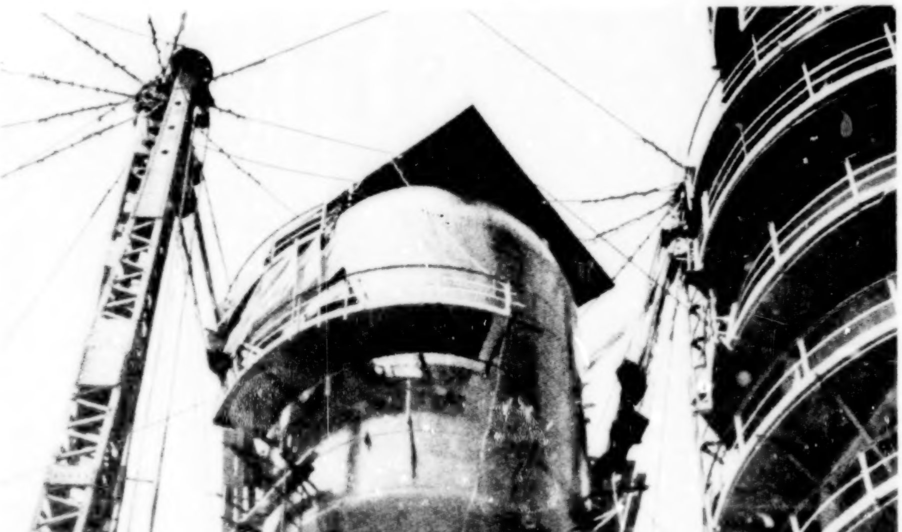
I. Oil Reserves

Academics, oilmen, government agencies, and trade organizations have made numerous attempts over the last decade to determine the amount of recoverable oil in China. The resulting estimates vary widely, and as yet no estimate or set of estimates has won widespread acceptance. This is not surprising since an accurate reserve study requires access to

- relevant Chinese and Soviet literature,
- current and historical collections of geological data on China,
- information on past and current operations of the Chinese oil industry, and
- worldwide catalogs of oil producing strata to use as analogs.

No study has had all of the information required. The Chinese themselves have not yet amassed all the necessary data.[2] Since guesswork and intuition have had to be substituted for most of the detailed information needed on Chinese geology and oil exploration activities, there probably is greater uncertainty in estimating oil reserves in China than for any other region of the world.

Chinese Communist historians trace geological surveys of China back to 1862, when an American began to survey north China. Other Americans and then Germans, Britons, and Russians followed. A Department of Geology was established within the Ministry of Industry in 1912, an Institute of Geology was created in Peking in 1913 to train geologists, the institute staffed a new Office of Geological Survey with 22 graduates in 1916, and a Department of Geology was established at Peking University in 1918. Other universities began to establish geology departments in 1927.



One of the 27 catalytic crackers used to break up the heavy hydrocarbon compounds common in Chinese crude oils.

The work of Li Ssu-kuang (T.S. Lee) and Huang Chi-ch'ing (T.K. Huang) capped Chinese geological accomplishments of the pre-1949 period. Both men proposed tectonic explanations of China's geology. Li won a measure of international recognition and lived long enough to assume a succession of ministerial-level posts in the Communist government and guide the Chinese oil industry through its infancy.

The cumulative efforts of foreigners and Chinese before 1949 barely began the arduous task of understanding China's geological makeup. In fact, the three oilfields opened prior to 1949 (Tu-shan-tzu, Yu-men, and Yen-ch'ang) were each located more by obvious surface bitumen and gas seeps than by subsurface exploration guided by geological knowledge. None was or is now a large producer. Chinese oil reserves were essentially untouched, to await discovery and development under the Communist regime.

Because pre-1949 geological information is meager and because Peking refuses to release the results of post-1949 exploration, only a few fundamentals about Chinese oil geology are known. Meyerhoff[3] lists 16 major sedimentary basins with oil-bearing potential, of which 12 exist entirely on land, 1 (North China) has about one-fifth of its area straddling the Po Hai[4] and 3 (Kiangsu, Taiwan, and Liu-chou) are mostly offshore (see Figure 1).

Of the land basins, all but two are in the northern half of the country; they total about 804,000 km^2 in the northwest and about 730,000 km^2 in the north-northeast. A Soviet geologist privy to the findings of exploration up to 1960 has written that hundreds of structures favorable for oil had been found but that the oil-bearing rock tended to be low in porosity and permeability.[5]

The offshore basins front on 18,000 km of coastline and may have a total area of 1.2 million km^2 containing at least 3 million km^3 of sediment of interest for oil exploration.

The onshore oil-bearing sedimentary basins are lacustrine or continental in origin except for the major parts of the Kwangsi-Kweichow Basin, 10 percent or less of the Tarim Basin, one-half the

Szechwan Basin, and the possible basins in Tibet not counted by Meyerhoff. By contrast, most of the large oil deposits of the world were formed and are trapped in a marine environment.

The world's important producing continental deposits of oil yield high-paraffin, medium- to high-gravity, very low sulfur crudes. The crudes from the three largest Chinese oilfields, which account for 80 percent of the national output of crude, conform to the pattern (see Figure 2).

China, despite its relatively backward oil technology, has 13 thermal and 27 catalytic crackers in its 44 refineries. These expensive facilities, highly unusual in such numbers except in the United States and the USSR, are indispensable for breaking up the heavy molecules in the very large percentage of residuum from primary distillation.[6] Acceptable yields of the more useful products such as gasoline, kerosene, diesel fuel, and naphtha feedstock for petrochemical plants would not otherwise be possible. The high paraffin content, the large percentage of residuum, and the Chinese refusal to adjust crude prices to compensate for them have been important obstacles to building up an export market.

China can look only partly to foreign technology as a shortcut for the exploration and development of its lacustrine basins. Geological research and development in most oil-producing countries have focused on exploitation of marine sedimentary deposits. Thus, there may be substance to China's claim to having been a pioneer in research on lacustrine sedimentology and the special problems of finding and exploiting continental deposits. A Soviet geologist who worked in China during the 1950s writes that theory on oil of continental—mainly lacustrine—origin was a Chinese specialty, that they were producing new theories and practices for oil prospecting.

The particular lacustrine reservoirs that China is depending on for 80 percent of its production—in north and northeast China—are complex, highly faulted formations with oil-bearing strata at many levels. Apparently, most reservoirs are in combination stratigraphic and structural traps.[7] These traps in lacustrine basins are characteristically random and not readily identified except by actual drilling. Drilling sites in eastern Chinese oilfields are scattered over wide areas. The geology of the large fields seems to have been as important as shortages of equipment and skilled manpower in explaining why 5-10 years have been spent to bring a new oilfield to a modest 100,000-200,000 b/d[8] output.

The risk inherent in estimating the rate of ultimate recovery of oil in exploitable pools is heightened by China's unusual geology. Maurice J. Terman of the USGS believes that Chinese lacustrine deposits may have as large a volume of hydrocarbons *in situ* as deposits in the Middle East but that perhaps only a small fraction will ever be recovered, because there are so many scattered, unexploitably small concentrations and because much of the hydrocarbons remains in the form of kerogen or oil shale.

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Figure 2

Analysis of Crude

	Ta-ch'ing	Sheng-li	Ta-kang
Gravity, °API	32 (light-medium)	20-24.6 (heavy)	Detailed analysis not available for Ta-kang crude. It is reported to be similar to Sheng-li crude.
Wax, hexane (% wt)	22.4	15.3	
Sulfur (% wt)	0.06-0.14	0.88-1.35	

Figure 3

Estimates of Chinese Recoverable Onshore Liquid Oil Reserves[1]

Estimator	Billion Barrels[2]	Remarks
Japan External Trade Organization	Total: 76.65-98.55[3] Land: 32.85 Po Hai: 43.8-65.7	Implications widely publicized by Selig Harrison[4]
Meyerhoff	Total: 45.2[5] Land: 39.6 Po Hai: 5.6	In 1970, he estimated 19.6 BB by totaling estimates for each field and structure.[1] He revised his total to 39.6 BB in 1975 and added a speculative figure of 5.6 BB for the Po Hai, but has not published the details of the revision.
Private Study	Total: 41-68	Statistical probability method. Figures reflect range of results derived.
USGS	Total: 33.6[6]	By sedimentary basin and US analogs. The preliminary figure from a study in progress.

1. For a definition of reserves, see Appendix A.
2. Including reserves under the shallow Po Hai but not deep offshore.
3. *Petroleum Times*, 11 Jul 75, p. 25.
4. Selig Harrison, *Foreign Policy*, No. 20, "Time Bomb in East Asia," fall 1975, p. 3-27.
5. A.A. Meyerhoff, *American Association of Petroleum Geologists Bulletin*, Vol 54, p. 1567-1580.
A.A. Meyerhoff, "China's Petroleum Potential," *World Petroleum Report* 1975, pp. 18-21.
6. The preliminary indications from a study still in progress.

Figure 4

A.A. Meyerhoff's 1970 Estimates[1] of Chinese Recoverable Onshore Liquid Oil Reserves

	Billion Barrels
Total	**19.6**
Total proved reserves	5.8
By basin	
Dzungarian	0.88
Tarim	0.05
Tsaidam	1.76
Turfan	0.05
Pre-Nan-shan	0.73
Chao-shui	Negl.
Min-ho	Negl.
Ordos	0.03
North China	0.40
Sung-liao	0.77
Hu-lun-ch'ih	....
Szechwan	1.12
Kwangsi-Kweichow	....
Probable reserves in known fields	1.2
Reserves in known but untested structures	5.6
Reserves in partly explored basins	7.0

1. Meyerhoff updated his total in 1975 to 39.6 BB, plus a speculation of 5.6 BB for the Po Hai.

in the world" is not helpful without elaboration, particularly on the crucial matter of category of reserves meant.

The Japan External Trade Organization (JETRO) estimate of 76.65-98.55 BB[11] of exploitable reserves onshore is the highest of any published. Selig Harrison's article "Time Bomb in East Asia" in the fall 1975 issue of *Foreign Policy* gave wide currency to JETRO's extreme optimism over China's oil prospects. Harrison's prediction that China by 1988 would emerge as a world oil power[12] rested solely on onshore reserves. He went on to say that within two decades, when it is presumed huge offshore reserves will be brought into production, China will rank among the world leaders in oil production.

JETRO estimates are not supported by published data or methodology. Harrison in a footnote ascribed some of JETRO's findings to the Nomura Research Institute, but its work is not available either. JETRO's optimism regarding China's oil future appears to be based on a straight-line extrapolation of past production rates. The volume of reserves, amount of capital, and level of technology, not to mention the size of foreign markets required to justify an annual output on the order of 8 million b/d by 1988, are assumed to be forthcoming. Professional geologists do not accept the JETRO-Harrison line.

Meyerhoff, an oil geologist with long experience in oil companies and the USGS, has done extensive research on Chinese oil reserves. His 1970 study, grounded in a review of data available in the USSR, was the first to offer a comprehensive analysis of Chinese reserves by someone with recognized credentials. His estimates, summarized by basin and oilfield, are given in Figure 4. Meyerhoff's overall estimate of Chinese onshore reserves of 19.6 BB is the sum of the estimates for each field, together with an allowance for potential reserves in known but untested structures and a second allowance for possible reserves in partially explored basins. The model's estimate is adjusted upward as drilling at each field confirms more oil deposits and as exploration outside the established oilfields progresses. Also, only reserves associated with particular oilfields are broken down geographically. In 1975, Meyerhoff raised his original estimate to 39.6 BB, probably from a greater appreciation of the role of Ta-ch'ing and Sheng-li fields. He did not publish a geographical breakdown. Criticism of his findings rests on his reliance on Soviet and Nationalist Chinese sources whose information was a decade or more out of date by 1970.

The private study is an effort to determine the potential influence of China on world oil availability. It is the most useful study of Chinese oil reserves to date because of its geographical breakdown. The lower figure of 41 BB is their preferred estimate. The higher figure of 68 BB is the estimate of maximum potential. See Figure 5.

The USGS is currently working on a basin by basin study of Chinese oil reserves. As of May 1976, the total area of potential oil-bearing sediment had been determined, but not the volume. Isolation of relevant strata for analogs with US strata for which histories of production are known will be the last step in estimating Chinese reserves.

Preliminarily, the sedimentary area ratio for the USSR, the United States, and China has been set at 3 to 2 to 1. The ratio for volume will be in the neighborhood of 3 to 5 to 1. The USGS has estimated US oil reserves, produced and identified, to be about 168 BB.[13] If the volume ratio holds up through the analog phase of the study, the reserves in China would be 33.6 BB, as shown in Figure 3.

Except for the JETRO figures, the reserve estimates do not vary greatly. None of them exceeds 100 BB, the largest amount that oil company geologists concede to have any chance of existing.[14]

Offshore Reserves

The wide Chinese continental shelf extending along the entire coastline from Korea to Vietnam has inspired the greatest foreign optimism over China's oil prospects (see Figure 1). The eastern shelf, extending from the tip of the Shantung Peninsula to Shan-t'ou and eastward to Japan, Korea, and Taiwan, has particularly drawn interest because of the huge volume of sediment left by the Huang Ho and the Ch'ang Chiang. A UN-sponsored report following a survey of the eastern coastline by the ship *R.V. Hunt* in late 1968 said that "there is a high probability . . . that the continental shelf between Taiwan and Japan may be one of the most prolific oil and gas reservoirs in the world." The project leader was removed following a barrage of criticism. It is true that the ship's equipment was unable to penetrate all of the formations most likely to contain oil, but penetration was sufficient within the potentially productive beds to justify reasonable optimism.

Paradoxically, many of the oil companies that criticized the UN report eagerly sought rights to explore off the east coast. The governments of Taiwan, Japan, and South Korea cooperated by blocking out lease areas extending roughly half way from their coasts to the Chinese coast in apparent hope that someday the Chinese will accept the equidistant principle for delineating the legal rights to the waters. Peking issued warnings about infringements of its sovereignty and began to build its own and to import offshore exploration equipment. To date, the oil companies have made no positive finds except for a gas pool off the southwestern corner of Taiwan. In the last two years, activity along the east coast has stabilized at a low level. The Chinese themselves have conducted one test drilling off the coast of Kiangsu Province, using a catamaran devised from two old ship hulls.

Obviously, then, the requisite data for formally estimating offshore reserves are not yet available. Meyerhoff emphasizes that the volume of sediment still has to be determined, and explicitly labels his estimate of offshore reserves of 30 BB as speculation.[15] The private study estimates offshore reserves to be in the order of 2-3 BB. The researchers, however, did not have the benefit of the latest seismic data on the continental shelf.

The most recent geological information, while clarifying the geology of the continental shelf, does not provide the data required for estimating oil reserves. The shelf is now seen as a buried remnant of the mainland, with a veneer of early Tertiary and more recent deposits. Such an interpretation tends to downgrade the oil prospects for the shelf.

There is general agreement among geologists that, along the east coast, the parallel northeast-southwest trending horst and graben structures which characterize all of onshore east China continue offshore to the edge of and beyond the present continental shelf. Terman's conclusion is that the difficulties of locating and exploiting oil in the stratigraphic traps to be expected in such a tectonic framework may prove uneconomical, given the additional difficulties imposed by the water cover.

Terman's view is justified by the Chinese record in coping with the similar graben complexes onshore. The achievement of 3.0 million b/d in nine years from formations similar to Sheng-li's and Ta-kang's, as predicted by one estimator, would represent a quantum jump in Chinese capability to develop oilfields even without the additional complication of the water cover.

Oil Shale

Finally, there are kerogen or oil shale deposits in China said by some geologists to be comparable to the vast oil shale deposits in the United States. Soviet geologists in China through 1960 reportrd 153.3 BB of shale reserves.[16] After some early efforts, the Chinese lost interest in exploiting shale. The shale operations at Fu-shun and Mao-ming have not been expanded for many years, and there are no indications of preparations for extracting oil from shale in other localities.

Conclusions on Reserves

The size of China's total oil reserves—onshore liquid, offshore liquid, and onshore shale—is still unknown. Analysis of the limited body of information available on onshore liquid reserves, performed both on a statistical probability basis and by totaling estimates done field by field and structure by structure, has yielded broad agreement on a range centering on about 40 BB of ultimately recoverable reserves, with the possibility that there may be as much as 100 BB. In comparison, as of mid-1976, remaining proved plus probable reserves were estimated to be 390 BB in the Middle East, 64 BB in Africa, 47 BB in North America, and 42 BB in Latin America.

China's onland reserves, though considerable, cannot support predictions of China becoming a world oil power. Moreover, a large and growing domestic demand for oil, the quality of many of the reserves, technological problems in extracting oil, and geopolitical considerations argue against continuous increases in exports.

- China presently consumes some 90 percent of its output, and domestic demand is increasing rapidly.
- Foreign buyers already are balking at quality-price relationships.
- Large imports of technology may be necessary to sustain recent rates of increase and will

Ta-ching Oilfield's famous "iron man", Wang Chin-hsi (middle with mustache), directing the installation of a drilling rig using human muscle because heavy equipment was not available in the early history of the field.

Figure 5

Private Study Estimate of Remaining Chinese Recoverable Onshore Liquid Oil Reserves

	Billion Barrels	
Sedimentary Basin in:	**Remaining Discovered Reserves[1]**	**Estimated Undiscovered Potential**
North and Northeast Region	4	13-26
Far West Region	10	10-22
Southern Region	2	2-4
Total	16	25-52

1. Excludes over 2 BB produced to date.

almost certainly be required to increase output more rapidly.

- The high cost of transportation—including use of tankers small enough to enter Chinese ports—and of heating the oil in transit—has tended to limit exports.
- Chinese officials differ over whether to increase exports or to save China's reserves for future domestic consumption.

Offshore reserves, although possibly very large, are as yet the subject of conjecture only. Even if very large, they may prove difficult and expensive to locate and extract. Neither the Chinese nor foreigners have yet acquired enough data on offshore sedimentary deposits to make valid estimates. Predictions about China's future as an oil power based on exploitation of offshore deposits are premature.

China's large shale deposits will be irrelevant in the next 10-20 years. The exploitation of shale would be prohibitively expensive and irrational as long as liquid oil is available.

Footnotes

1. Throughout this report, the following abbreviations have been used: billion barrels (BB), degrees gravity as defined by the American Petroleum Institute (°API, gravity), metric tons (t), million metric tons (mt), percentage by weight (% wt), percentage by volume (% vol), degrees celsius (°C), parts per million (PPM), barrels per day (b/d), kilometers (km), square kilometers (km^2), and cubic kilometers (km^3).

2. For an idea of the degree of detail in information needed, see US Geological Survey Circular 725, ***Geological Estimates of Undiscovered Oil and Gas Reserves in the United States***, Appendix.

3. A.A. Meyerhoff, ***American Association of Petroleum Geologists Bulletin***, "Developments in Mainland China, 1949-68," vol. 54, No. 8, Aug 70, p. 1567-1580.

4. Po Hai is the correct rendition of the body of water commonly called the Gulf of Pohai. Hai in Chinese in this case means gulf.

5. G. Ye Ryabukhin, ***Geologiya v Kitaya***, Moscow, 1960. Translated in JPRS 3672, 10 Aug 60, p. 15.

6. The initial process in refining is to heat the crude oil in a distiller that bleeds off constituents of the crude according to the temperature bands in which they vaporize. The portion of the crude left unvaporized after the highest practical temperature for the distiller has been applied is the residuum.

Ta-ch'ing crude, which amounted to 54% of national crude output during 1975, has a residuum (unvaporized at °C 343) of 68.0%. The residuums for the common crudes in the world oil trade of close to 32° API gravity (the weight of Ta-ch'ing crude) are as shown in Figure 6.

7. A stratigraphic trap is formed when oil migrating laterally through permeable, porous strata encounters an impervious or relatively impervious barrier created by a change in facies. Stratigraphic traps are difficult to locate by geophysical surveys. Most oilfields in the world have structural traps, particularly of the anticlinal variety in which oil is trapped in arch-shaped structures. Most arch-shaped structures are easy to locate by seismic surveys.

8. Crude oil is not uniform in weight. At 15.6°C, it consists of between about 6.98 and 7.73 barrels per ton, representing API gravities of between 25° and 42°, respectively. The conventional conversion factor of 7.3 barrels to the ton used in this report is justified by the easy change it allows between tons per year and barrels per day. One million b/d equals 50 mt per year. The most common type of Chinese crude is API gravity 32° and has 7.28 barrels to the ton

Figure 6

Crude	Origin	Gravity, °API	End Temperature (°C)	Residuum Percentage
Arabian light	Saudi Arabia	33.4	343	46.1
Iranian light	Iran	33.5	343	45.4
Darius	Iran	33.9	327	41.03
Basrah	Iraq	33.9	343	44.54
Kuwait crude	Kuwait	31.2	360	47.53
Minas	Indonesia	35.2	343	56.5
Sassan	Iran	33.9	371	39.7
Gulf of Suez blend	Egypt	31.5	366	47.0
Reforma (Cactus Reforma Isthmus)	Mexico	33.0	343	45.3
Trinidad blend	Trinidad-Tobago	33.6	343	31.2

9. Defined to include reserves under the shallow Po Hai. These reserves are in formations that are extensions of adjacent onshore oilfields.

10. Shell Oil in 1973 circulated an estimate of 19.98 BB of "recoverable oil" in established oil-bearing areas.

World Petroleum in 1974 estimated 300 BB, including offshore.

World Oil on 15 Aug 74 esimtated 14.8 BB "proved."

Iraqi geologists who visited China in 1971 afterwards estimated 12.4 BB "proved plus probable."

Park Choon-ho in 1974 estimated 44.74-74.4 BB on the mainland. (In testimony before the House Subcommittee on Asian and Pacific Affairs of the Committee on Foreign Affairs on 30 Jan 74.)

Jan-Olaf Willums estimates 20 BB offshore along the east coast.

11. ***Petroleum Times***, 11 Jul 75, p. 25.

12. Harrison based his comparison with the Saudi Arabia of 1974, i.e., an output of 8.24 million b/d.

13. Betty Miller et al., Geological Survey Circular 725, 1975, "Geological Estimates of Undiscovered Recoverable Oil and Gas Resources in the United States," 1975.

14. Hardy, Randall W., *Chinese Oil Developments and Prospects and Potential Impact*, Washington, D.C., Georgetown University Center for International Studies, November 1976. His information is from interviews with geologists of two large oil corporations.

15. Reported by Harrison from conversations with Meyerhoff as 12.84 BB for the East China Sea, 5.60 BB for the Po Hai, 8.03 BB for the South China Sea, and 5.60 BB for the Yellow Sea.

16. Y.I. Brezina, *Toplivno energeticheskaya baza Kitayskay Norodnoy Respubliki*, Moscow, 1959. Translated in JPRS 3784, 31 Aug 60.

II. Crude Production

China's production of crude oil was insignificant before the Communist takeover of 1949. The new government inherited three oilfields–Yu-men, Tu-shan-tzu, and Yen-ch'ang–which had an aggregate output of less than 2,000 b/d. None of these fields had the potential to become large producers. In addition, two shale plants in Fu-shun built by the Japanese during the occupation of Manchuria had a combined capacity of producing about 1,000 b/d of liquid oil annually.

Traditionally, China relied on coal for a large part of its energy needs. In the 1950s the limited requirement for liquid fuels and lubricants was supplied mostly by the Soviet Union. Imports rose from about 4,000 b/d in 1949 to a peak of about 66,000 b/d in 1960. With the opening of the Ta-ch'ing Oilfield in that year, imports tapered off rapidly. By 1963, Ta-ch'ing output of crude reached 88,600 b/d and Peking claimed self-sufficiency in oil for China. Imports of 34,000 b/d in 1963 still composed more than 20 percent of total supply; in 1964 the portion fell to 8.7 percent and since then imports have represented less than 3 percent of total supply.

The opening of the Ta-ch'ing Oilfield in 1960 and the Sheng-li Oilfield in 1962 marked a shift of the largest producing oilfields from the far west to the north and northeast (see Figure 1). The latter regions were and still are the most heavily industrialized in China. Ta-kang Oilfield in Hopeh Province, in the north region, started producing in 1967. These "big three" in 1975 accounted for 80 percent of national output.

As of yearend 1975, China had at least 30 oilfields and 6 exploratory sites.[17] Of these, 14 probably produce 10,000 or more b/d each, as shown in Figure 8.

Figure 7 presents estimates of Chinese crude oil output nationally and by selected fields. Since each series was calculated from an independent set of data,[18] each year's total of output at individual fields can be checked against the national output for the same year. The residuals include shale oil and oil from some very small fields and three large fields for which data are not available, plus or minus the cumulative errors attributable to the impreciseness of Chinese claims. In most of the years through 1969, shale oil and oil derived from coal–perhaps as high as 34,000 b/d in most years since 1959–account for a large share of the residual. In some years, notably 1962-64, the residual appears too small to include both shale oil and the output of the small fields. These were years of recovery from the chaos of the Leap Forward (1958-60), during which statistical falsifications and confusion were rampant, and estimates for individual fields–especially Ta-ch'ing–may be too high. On the other hand, the confusion and technical prob-

Figure 7 **Crude Oil Production**

Million Metric Tons

	National	Ta-ch'ing	Sheng-li	Ta-kang	Yu-men	K'o-la-ma-i	Tsaidam[1]	Residual
1949	0.121							0.121
1950	0.200							0.200
1951	0.305							0.305
1952	0.436				0.143			0.293
1953	0.622				0.198			0.424
1954	0.789				(0.239)[2]			0.550
1955	0.966				0.414			0.552
1956	1.163				0.533			0.630
1957	1.458				0.755	0.05		0.653
1958	2.264				1.002	0.25	0.03	0.982
1959	3.7				1.337	(0.239)	(0.044)	2.080
1960	5.1	0.792			1.700	(0.226)	(0.058)	2.324
1961	5.186	(1.022)			1.600	(0.214)	(0.072)	2.278
1962	5.746	(2.726)	0.046		(1.303)	0.201	(0.085)	1.385
1963	6.360	4.427	(0.321)		(1.006)	(0.307)	(0.099)	0.200
1964	8.653	(5.765)	0.596		(0.709)	(0.416)	(0.113)	1.054
1965	10.961	7.106	0.735		0.412	0.523	0.127	2.058
1966	14.074	8.776	2.0		(0.414)	(0.473)	(0.135)	2.276
1967	13.9	(9.045)	(2.625)	0.20	(0.416)	(0.423)	(0.144)	1.046
1968	15.2	9.297	(3.250)	(0.34)	(0.417)	(0.373)	(0.152)	1.371
1969	20.377	12.830	(3.875)	0.48	0.419	0.323	0.160	2.290
1970	28.211	17.666	4.5	0.96	0.490	0.384	0.165	4.046
1971	36.700	22.136	6.5	(1.64)	0.544	0.503	0.180	5.197
1972	43.065	25.550	8.45	(2.33)	0.620	0.604	0.320	5.191
1973	54.804	28.298	9.50	3.00	0.676	0.725	0.442	12.163
1974	65.765	34.608	11.02	3.74	0.710	1.036	0.530	14.121
1975	74.261	40.072	14.90	4.34	0.785[3]	1.065[3]	0.582[3]	12.517
1976	83.608	43.093						
Total	503.994	273.209	68.318	17.030	16.842	8.335	3.438	
	3.679 BB	1.994 BB	0.499 BB	0.124 BB	0.123 BB	0.063 BB	0.024 BB	

1. Actually consisting of three separate fields.
2. Parens indicate linear interpolation.
3. Regression analysis, 1969-74.

lems following the withdrawal of Soviet technicians in 1960 may have sharply depressed output of the shale oil plants and the small oilfields.

The residuals for 1970-75 include the output of three large fields for which output data are not available. Figure 10 presents estimates of the likely upper limit for output at each of the three fields.

To the output of the three fields must be added the shale oil produced annually at the Fu-shun Shale Plant West (10,000 b/d), Fu-shun Shale and Chemical Plant East (8,000 b/d), and the Mao-ming Shale Oil Plant (10,000 b/d), as well as the liquid oil produced from coal at the Fu-shun Coal Liquefaction Plant (6,000 b/d).

Figure 9 shows the final residuals for 1970-75 after subtraction for shale oil and for Fu-yu, P'an-shan, and Ch'ien-chiang, and the percentages they represent of the estimated national crude oil production each year.

These final residuals represent the output of a number of very small fields plus the cumulative errors in the seven series in Figure 7. The sign of the errors is not important because of the impreciseness in the original Chinese claims backing the seven series. The size of errors—which are less than 10 percent—is within the range to be expected given the paucity of Chinese official economic statistics.[19] For 1975, the negative residual compared with 50,000 b/d for 1974 indicates that the likely upper limits for the three fields were larger than actual production.

Figure 8 **1975 Output at Significant Oilfields**

	Million Metric Tons	Thousand b/d
North and Northeast region		
Ta-ch'ing	40.03	801
Sheng-li	14.90	298
Ta-kang	4.34	87
P'an-shan	4.05[1]	81[1]
Fu-yu	3.25[1]	65[1]
An-kuang	Less than 1	Less than 10
Yen-ch'ang	Less than 1	Less than 10
Far West region		
K'o-la-ma-i	1.07	21
Yu-men	0.78	16
Tu-shan-tzu	Less than 1	Less than 10
Tash-arik	Less than 1	Less than 10
Leng-hu	Less than 1	Less than 10
Southern region		
Ch'ien-chiang	4.10[1]	82[1]
Nan-ch'ung	Less than 1	Less than 10

1. Likely upper limit.

Figure 9 **Final Residuals of Crude Oil**

	National Crude Output		Final Residuals (Million Metric Tons)	Residual as Percent of National Output
	Million Metric Tons	Million Barrels per Day		
1970	28.21	0.564	-0.09	-0.32
1971	36.70	0.734	-0.89	-2.43
1972	43.07	0.861	-3.94	-9.15
1973	54.80	1.096	1.80	3.28
1974	65.77	1.315	2.54	3.86
1975	74.26	1.485	-0.58	-0.78

Figure 10 **Likely Upper Limits of Crude Oil Production at Selected Fields**

Million Metric Tons

Field d	1970	1971	1972	1973	1974	1975
Total	2.44	4.39	7.43	8.66	9.88	11.40
	48,800 b/d	87,800 b/d	148,600 b/d	173,200 b/d	197,600 b/d	228,000 b/d
Fu-yu	(1.15)[1]	1.44	2.58	2.83	3.08	3.25
P'an-shan	0.14	0.74	1.57	(2.20)	2.83	4.05
Ch'ien-chiang	(1.15)	(2.21)	3.28	3.63	3.97	4.10

1. Parens indicate interpolation or extrapolation.

Footnotes

17. Meyerhoff in his 1970 study listed 40 fields confirmed and probable. Discrepancies arise over the count of fields because some counts include fields left out of other counts as too small to be significant and because a single field by one count may be split up into two or more fields in another count.

18. For derivation and sourcing of each series, see Appendix E.

19. To see how the national crude output estimates since 1965 fit with estimates of refining capacity, see Appendix D.

III. Major Oilfields

Ta-ch'ing Oilfield (46-33-00 N, 124-58 E)

Ta-ch'ing is the core of the Chinese oil industry, accounting for 54 percent of national output in 1975. Since acknowledgement of its existence by the Chinese media in the early 1960s, Ta-ch'ing has been trumpeted as a synonym for industrial achievement through self-reliance. "Emulate Ta-ch'ing" campaigns are a staple of Chinese industrial life.

The truth, however, is that the exploration which located the field was carried out under the guidance of Soviet and East European technicians. During 1960, the first year of production at the field, all Soviet technicians withdrew from China. Alone, the Chinese required 5 years to bring the field to an annual output of 116,000 b/d, 10 years to 256,000 b/d. The technology used in developing the field during its first decade was entirely Soviet or East European.

Ta-ch'ing is in Heilungkiang Province, in the northern half of the Sung-liao Basin. The reservoirs are a number of sandstone strata on a very broad arch. Meyerhoff reports the field as consisting of more than 22 Mesozoic (Lower Cretaceous) sandstone reservoirs at depths as great as 1,500 meters. The developed areas (see Figure 12) representing the field cover approximately 1,200 km^2.

The Sung-liao Basin itself is some 150,000 km^2 in area and is characterized by broad, gently dipping arches and domes. Other existing fields in the Basin are at Fu-yu and An-kuang. The initial geological survey took place in 1951 and exploratory drilling began in 1959.

Unlike most Chinese fields, Ta-ch'ing is almost all in one contiguous area. The difficulties encountered at the field were primarily from inexperience and the harsh winter weather. Wells are reportedly at easy depths of 305-1,370 meters. The one crisis admitted by the Chinese in management of the field took place during the early stage, when water injection was commenced prematurely and led to migration into unintended areas. An intensive underground mapping program solved the problem. One foreign visitor to Ta-ch'ing has estimated that the majority of Ta-ch'ing's wells were injection type.

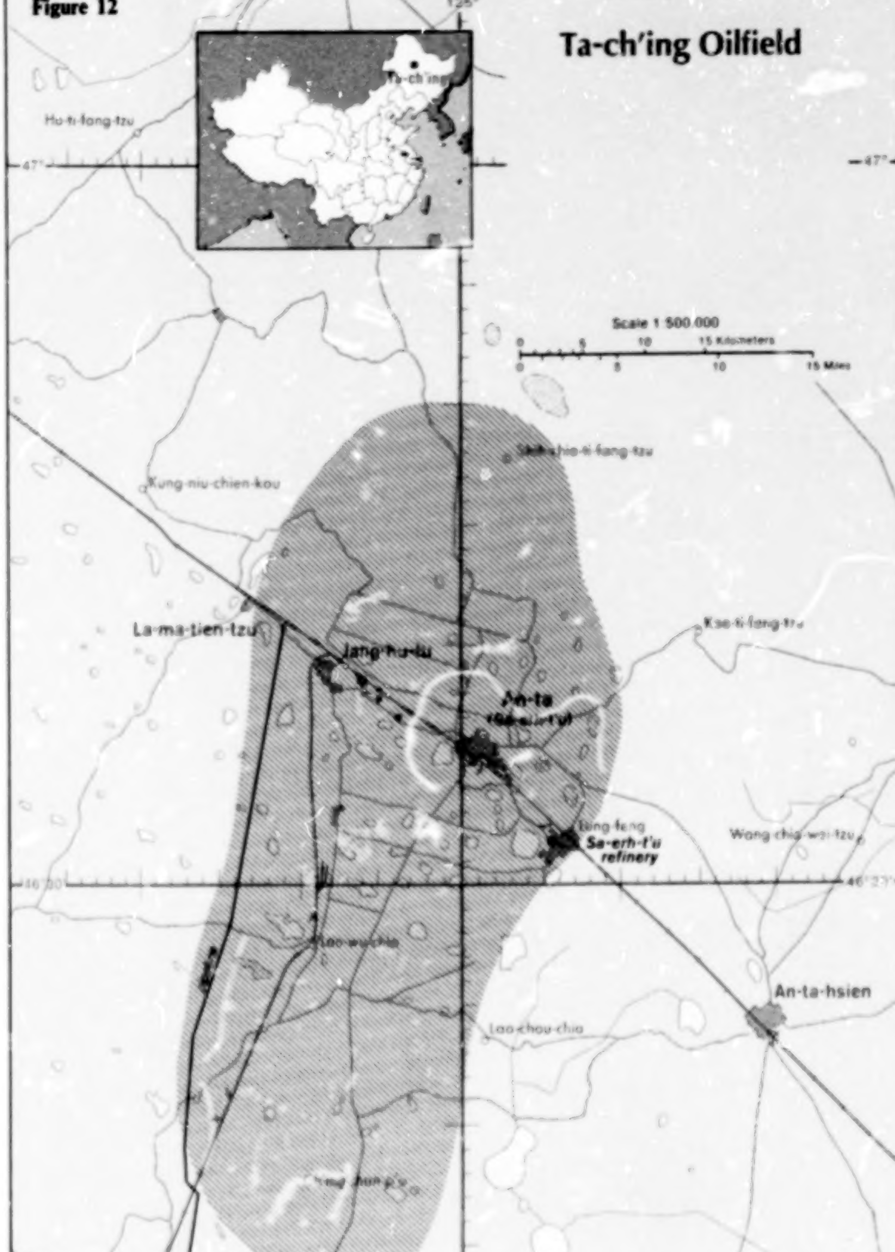
The crude oil produced at Ta-ch'ing is a consistent high-paraffin, low-sulfur, light-medium variety. The crude analysis appears in Figure 11.

Almost 120,000 b/d, or about 15 percent of 1975 output, was refined onsite. The main refinery, at Sa-erh-t'u, has a capacity of 84,000 b/d; the smaller units at La-ma-tien and Ching-chia-wei-tzu are of 14,000 b/d and 20,000 b/d capacity, respectively. Most of the field's

Figure 11 **Ta-ch'ing Crude Oil**

Crude Analysis		Product Yield (% vol)	
°API gravity	32	Liquid petroleum gas	0.2
Specific gravity	0.8588	Light naphtha	5.4
Pour point, °C	32.2-35	Naphtha	3.7
Salt content, % vol	0.001-0.003	Kerosene	4.7
Sediment, % vol	0.2	Gas oil	6.9
Sulfur, % wt	0.06-0.14	Heavy gas oil	7.0
Wax, hexane, % wt	22.4	Residuum	68.0
Nickel, calculated PPM	3.2	Water	2.6
Nitrogen, PPM	1,600	Loss	1.5
Vanadium, calculated PPM	0.1		

Figure 12



skilled manpower in explaining why 5-10 years have been spent to bring a new oilfield to a modest 100,000-200,000

6. The preliminary indications from a study still in progress.

5

output goes out by dual pipelines built from pre-1972 through 1975. One pipeline traverses the Manchurian valley, serving the urban and industrial concentrations along the way, passes through the port of Ch'in-huang-tao, and continues south of Peking to one of China's largest and most modern refinery-petrochemical plants, at Fang-shan. The other pipeline also traverses the Manchurian valley, but diverges at T'ieh-ling to go through the Liao-tung Peninsula to the two ports at Lu-ta, at one of which facilities were completed in mid-1976 for berthing 100,000 DWT or larger tankers in support of oil exports.[20]

Ta-ch'ing is also served by rail transfer points. The railroads probably hauled as much as 300,000-400,000 b/d of oil from Ta-ch'ing before 1974. The pipelines have pushed rail transportation into the background.

Ta-ch'ing supplied 85-90 percent of all Chinese crude exports in 1975. Abroad, the crude is considered troublesome to refine as a distinct type unless equipment especially designed for it is built. The Japanese either send Ta-ch'ing crude to steel and powerplants for fuel or blend it with other crudes before refining. The nitrogen content of the crude concerns Japanese fuel users anticipating more stringent legal restrictions on nitrogen-oxygen compound emissions. More than 94.9 million barrels have been delivered to Japan since late 1973 at prices ranging from less than $3 in 1973 to more than $14 during the Arab embargo crisis. The late 1976 f.o.b. price was $12.30, lower than similar Indonesian crude for Japan but higher than OPEC.

As oil output has increased at Ta-ch'ing so has gas output. Gas is partially flared and partially sent to a nearby nitrogen fertilizer plant. The Ta-ch'ing field as a whole produces enough gas as a byproduct to fire equipment and heat pipes and workers' quarters exclusively with gas. The regime since 1975 has shown increasing concern to profit more from the gas from Ta-ch'ing and other oilfields, either by piping more to cities and industrial plants or by liquefying it for export.

Ta-ch'ing's annual rate of increase in output has been falling off, suggesting that the growth rate has passed its peak. Since 1972, only during 1974 did the increase match or exceed the average annual rate of about 20% that had prevailed since 1963, when production at Ta-ch'ing settled down after several years of frantic preparatory development efforts.

Sheng-li Oilfield (37-30 N, 118-30 E)

The many active areas totaling 600 km^2 scattered along both banks of the mouth of the Huang Ho and near Lin-i at the base of the Shantung Peninsula, are designated as one oilfield, Sheng-li, by the Chinese (see Figure 14). Discovered not long after Ta-ch'ing and reportedly possessing reserves of comparable size, Sheng-li has been developed much more slowly. After 14 years, production at Sheng-li reached 300,000 b/d, whereas Ta-ch'ing attained an annual output of 800,000 b/d after 16 years. Nevertheless, Sheng-li in 1975 was by a wide margin China's second largest oilfield, accounting for 20 percent of total crude output.

Geologically, Sheng-li and its neighbors—Ta-kang and P'an-shan oilfields—are in the North China Basin in one of a series of grabens extending east-northeast to west-southwest and northeast to southwest across the North China Plain. Production is from Miocene-Pliocene and Upper Tertiary strata where a wide variety of stratigraphic traps are situated. Wells are reported to be 1,800-5,000 meters deep. Meyerhoff estimates depth to basement at probably 4,200 meters with the maximum thickness of the Tertiary section at 775-4,100 meters. One of the producing areas—near Chun-hua—has a limestone oil-producing stratum. Another location reportedly yielded radioactive material and had to be shut in. Meyerhoff believes there is a possibility of some marine deposits in the North China Basin, but Terman suggests that all deposits, including possible limestones, are lacustrine in origin.

Sheng-li's development might have been faster had not Ta-ch'ing been given priority in money, skilled manpower, and equipment. As late as 1975, Sheng-li's equipment and safety practices were still appallingly poor, according to visitors conditioned by the better situation they had seen at Ta-ch'ing. The resources required for building Sheng-li could not have been less than for Ta-ch'ing. The Shantung Peninsula weather also is severe, the underground formations to be located and mapped evidently are more complex, dikes had to be built to reclaim land along the marshy shoreline of the Yellow River delta, and drainage had to be maintained during rainy seasons.

The Chinese acknowledge problems at Sheng-li. They say that drilling is troublesome, with formations suddenly soft and suddenly hard. Small reservoirs are spread out in unpredictable patterns in the widely scattered active areas. Underground permeability and pressure conditions vary. In production, some reservoirs are pumped, some water-injected, and some fractured or acidized to promote a flow of oil through the reservoir rock. The field's management and personnel reportedly are still overwhelmed by the problems related to inconsistency in characteristics of oil produced and water and salt removal.

In Figure 13 the average analysis of Sheng-li crude has been culled from various laboratory studies of samples freely available to interested parties.

The Chinese say that their crude

A section of the Fang-shan refinery and petroleum works: The sign says, "The Chinese people have the will and the ability certainly to catch up with and surpass the world's advanced levels before long."

garding China's oil future appears to be based on a straight-line extrapolation of past production rates. The volume of reserves, amount of capital, and level of identified, to be about 168 BB.[13] If the volume ratio holds up through the analog phase of the study, the reserves in China would be 33.6 BB, as shown in Figure 3. mates offshore reserves to be in the order of 2-3 BB. The researchers, however, did not have the benefit of the latest seismic data on the continental shelf.

6

yields atmospheric distillates of only 15-23 percent, even worse than indicated by the analyses by foreigners.

Sheng-li has three associated refineries. The Wang-chu-chuang complex of 90,000 b/d annual capacity handles part of the output of the producing areas in the Huang Ho delta. The Chi-nan Refinery, which has a capacity of 34,000 b/d, and the Chi-nan Li-cheng Refinery, capacity 20,000 b/d, are inland and probably handle primarily the output from the Lin-i area. At the refineries, residuum is fed to vacuum distillers and the vacuum residuum is used to make asphalt. The vacuum distillates are fed to catalytic crackers. Dry gas and liquid petroleum gases from the refining process become fuel and raw materials for ammonia synthesis.

Sheng-li is served by rail transfer points, a pipeline to the port of Huang-tao, which serves primarily coastal tanker traffic, and a pipeline not yet completed to Nan-ching. Sheng-li crude also is distributed to the farthest reaches of south China.

About 14.6 million barrels of Sheng-li crude have been exported since 1974. All but a few hundred thousand tons went to the Philippines. Romania is the other customer of consequence. Laboratory size samples measured in barrels have been sent to Australia and New Zealand. Sheng-li crude sells in the range of $7-$9 a barrel. The price reflects its true worth, given its poor product yield and high content of paraffin and other impurities. So far, Japan, New Zealand, and Australia have refused to buy it despite the price.

Sheng-li's annual rate of growth has been more erratic than for Ta-ch'ing or for the oil industry as a whole. The increase of 35 percent in 1975 compared with 16 and 12 percent for 1974 and 1973, respectively. A 44 percent rate of growth was achieved in 1971. Nevertheless, reserves are large enough so output should grow rapidly for some years to come.

Ta-kang Oilfield (38-43 N, 118-33 E)

Ta-kang and Sheng-li are designated separate fields by the Chinese, but the clusters of active areas that make up each field are only 50 km apart and share practically identical geology. Meyerhoff sees the structures of Ta-kang as possibly more complex and severely faulted. Output of oil, which began in 1966, reached 87,000 b/d in 1975. Ta-kang, despite nine years of development, barely edges out Ch'ien-chiang as China's third largest field.

Large-diameter pipeline being laid.

One source describes Ta-kang as a highly faulted and fractured structural nose running northeast-southwest and plunging in the northeast direction. Displacements in the faults are 15 to more than 90 meters. Another source reported Ta-kang as consisting of "an anticlinal high with oil reservoirs broken by faults into a series of fault-blocks, with oil and gas contact in each block redistributed by titling," confirming reports in Chinese media that development of the field has been complex. Some oil layers are very thin, some very thick. Some have high yields, some low. Some wells gush oil, some water.

The field is entirely Tertiary. There are 13 oil sands totaling 37 meters of net pay. Three biogenic limestone oil zones have been found, and production has started in seven areas. Oil-bearing strata appear and disappear irregularly, and output at producing wells often fluctuates widely. Most wells reportedly are free-flowing. Meyerhoff reports a dry hole rate of 30 percent to more than 50 percent.

The oil formations extend into the Po Hai. The pay zones reportedly increase in thickness in the offshore direction, reaching 2,000-3,000 meters in depth.

Before the development of the field proper could begin, a land reclamation project lasting through 1966 had to be undertaken in the uninhabited salt flats that constituted the surface areas of the present field. NCNA reports that one-half the "technical force" and machinery were transferred to other new oilfields in 1970, after output, capacity, and reserves had been doubled over 1968-69. Judging by the reports from visitors of dangerous equipment and safety conditions at the field in 1975, it would appear that there has not been a renewed influx of skilled manpower and machinery to Ta-kang since 1970; this is one reason development of the field has been slow.

Offshore work in the Po Hai probably is run by Ta-kang rather than Sheng-li Oilfield, judging by the continuity of the formations onland with those offshore. Exploration had begun by late 1969. At least one production platform is in operation in the Po Hai.

Very little if any Ta-kang crude has yet been exported, so no detailed analysis

Figure 13 **Sheng-li Crude**

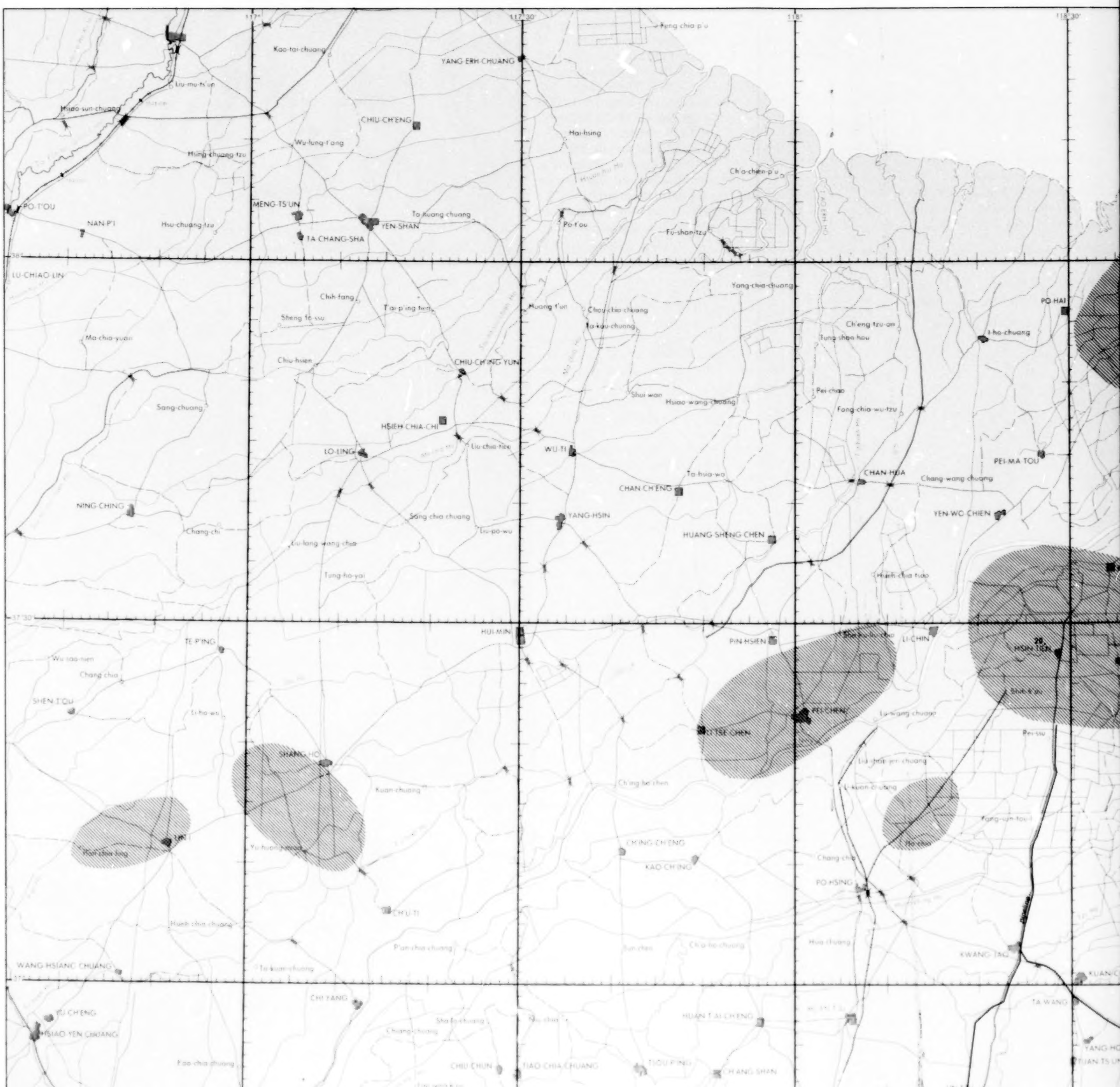
Crude Analysis		Product Yield (% wt)	
°API gravity, 15.6 °C	20-24.61	Liquid petroleum gas	....
Specific gravity, 15.6 °C	0.9185	Light naphtha	....
Pour point, °C	12-28.3	Naphtha	7.3
Sulfur, % wt	0.88-1.35	Kerosene	5.0
Salt, % vol	0.02-0.07	Gas oil	9.6
Water, % vol	0.7-2.0	Heavy gas oil	....
Nitrogen, PPM	5,100	Residuum	77.1
Paraffin, % wt	15.3	Water	....
		Loss	1.0

mated to be 390 BB in the Middle East, 64 BB in Africa, 47 BB in North America, and 42 BB in Latin America.

China's onland reserves, though con-

Total	16	25-52

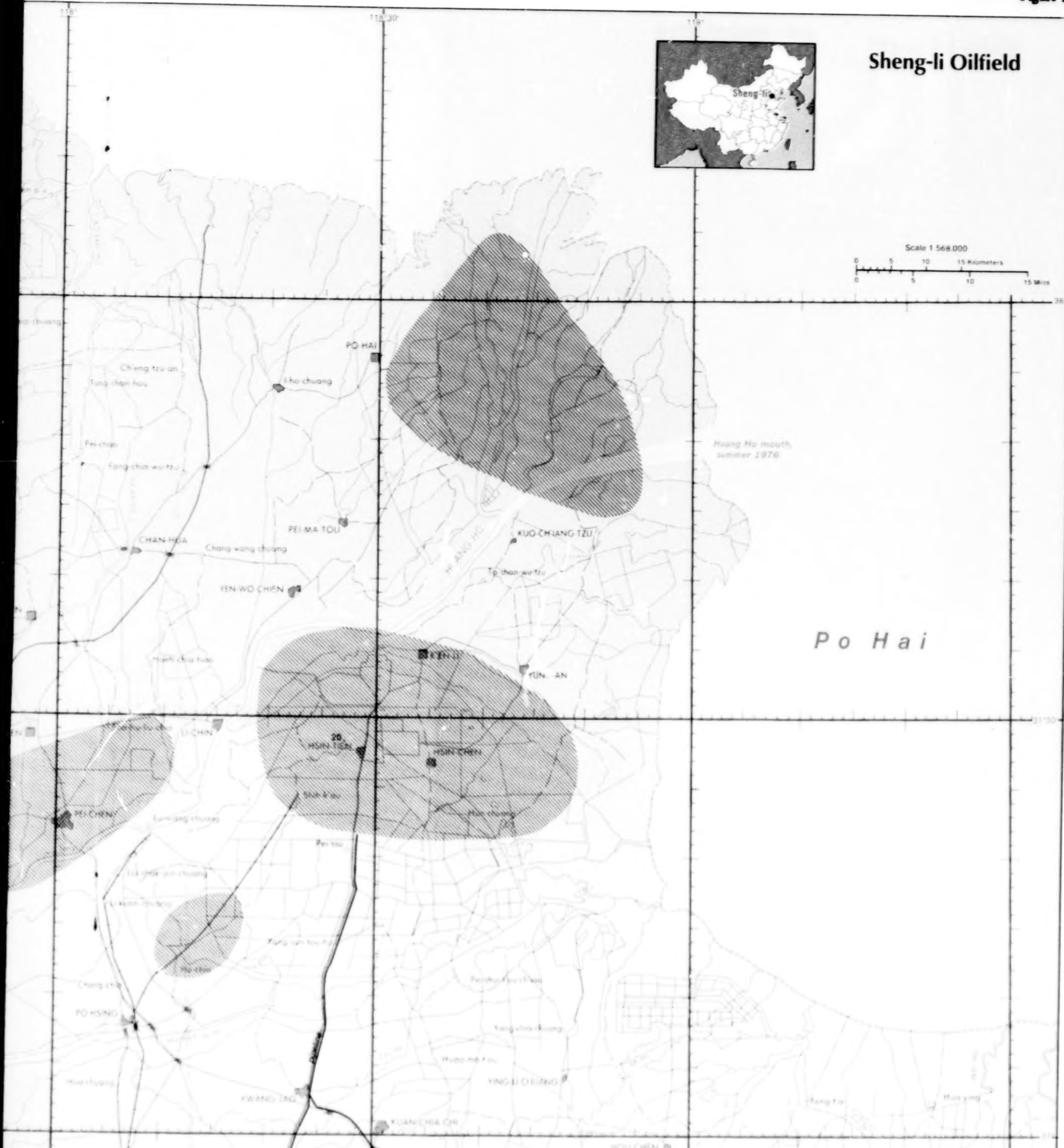
1. Excludes over 2 BB produced to date.



Reforma Isthmus)	Mexico	33.0	343	45.3
Trinidad blend	Trinidad-Tobago	33.6	343	31.2

16. Y.I. Brezina, *Toplivno energeticheskaya baza Kitayskay Norodnoy Respubliki*, Moscow, 1959. Translated in JPRS 3784, 31 Aug 60.

Figure 14



1. Actually consisting of three separate fields.
2. Parens indicate linear interpolation.
3. Regression analysis, 1969-74.

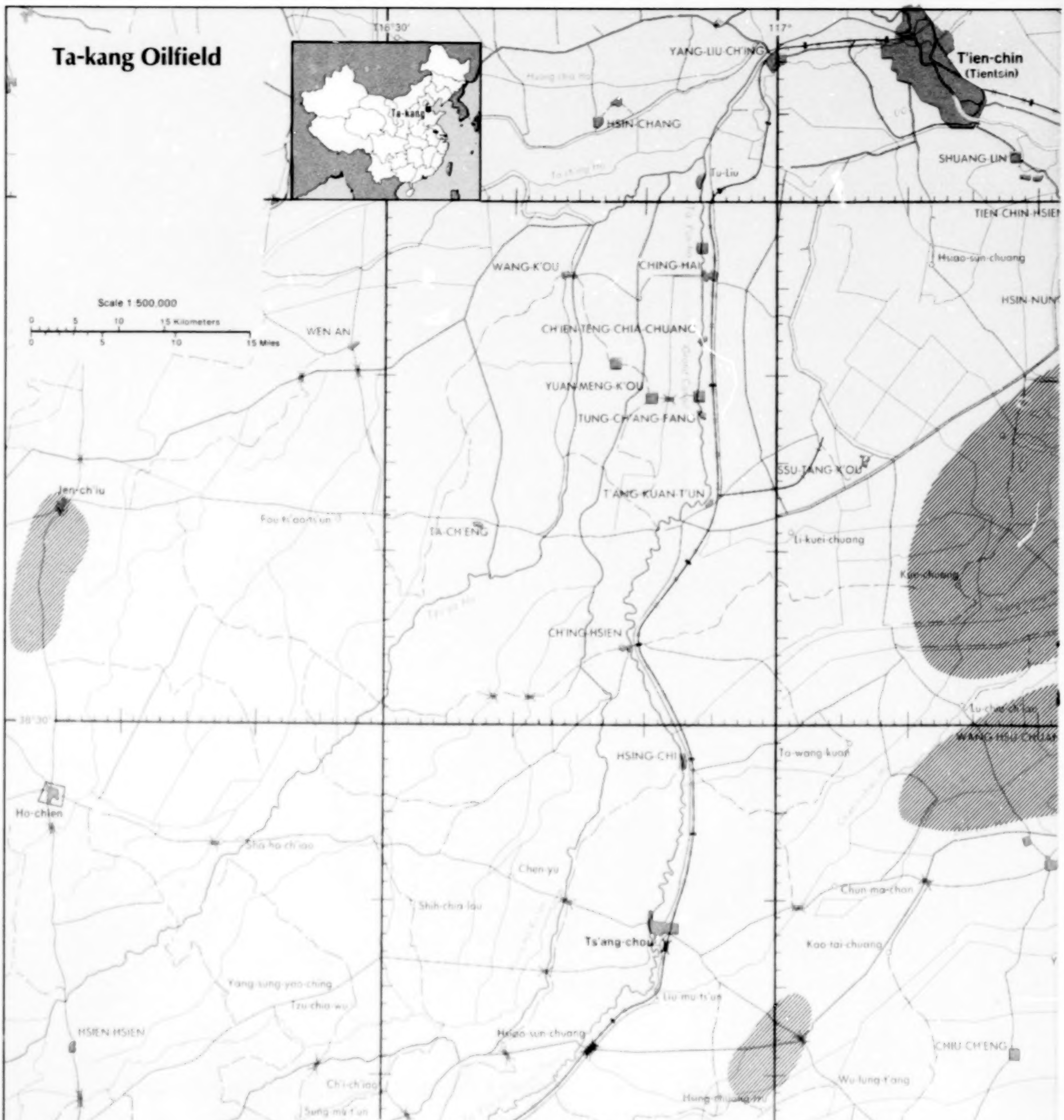
of its characteristics is available. The mainland media describe Ta-kang crude as "high quality like Ta-ch'ing's, with a sulfur content slightly higher than Ta-ch'ing's 0.2 percent [sic]. "The Hong Kong Communist controlled *Ta Kung Pao* characterizes Ta-kang crude as "fairly good quality ... ." Reports from a variety of sources give the specific gravity as 0.8, paraffin content as 10 percent, and water content as negligible. The associated gas is sweet smelling, that is, free of sulfur dioxide. The crude is thick enough to require heating in order to pump it in the winter.

Ta-kang has three refineries–Ts'ang-chou, (20,000 b/d), Ta-ku (14,000 b/d), and T'ien-chin (50,000 b/d). Two others–Yang-liu-ch'ing (16,000 b/d) and Pao-ting (30,000 b/d) are close by.

Ch'ien-chiang, P'an-shan, and Fu-yu Oilfields

These are the fourth, fifth, and sixth largest oilfields in China. They each accounted for 4-5 percent of 1975 national

Figure 15



P'an-shan	0.14	0.74	1.57	(2.20)	2.83	4.05
Ch'ien-chiang	(1.15)	(2.21)	3.28	3.63	3.97	4.10

1. Parens indicate interpolation or extrapolation.

output; thus each is only slightly smaller than Ta-kang in output.

Ch'ien-chiang

Ch'ien-chiang Oilfield (30-28 N, 112-45 E) is just north of the Ch'ang Chiang in Central Hupeh Province. Ch'ien-chiang's location is particularly important because oil can be transported to the southern provinces at lower cost than is the case for any other large field. The other known fields in or near the south are the Nan-ch'ung field in Szechwan Province, which probably produces less than 20,000 b/d, and the small shale oil field at Mao-ming in Kwangtung Province.

Ch'ien-chiang has been in existence for at least eight years. The Chinese apparently are uncertain over its long-term prospects. Possible causes of this uncertainty are a low amount of identified reserves or high cost of exploitation because of geological features of the field. In any event the field's prime location relative to the oil-deficient south provides a strong inducement to exploit reservoirs that might be judged marginal in the north and northeast.

Nothing is known about the geology of Ch'ien-chiang. The Soviet geologists who were in China during the 1950s when the exploration leading to the discovery of the field was carried out do not mention it in their reports. Nor is anything known about the characteristics of Ch'ien-chiang crude; none has been exported. A pipeline may well connect Ch'ien-chiang with the nearby Ching-men Refinery (40,000 b/d). The remainder of Ch'ien-chang's crude output probably goes to the Wu-han Refinery (34,000 b/d) and the Lin-hsiang Refinery (50,000 b/d). The latter two probably are also supplied crude brought by coastal tanker from the northern fields to the Shanghai–Nan-ching area and transshipped farther up the Ch'ang Chiang.

P'an-shan Oilfield

P'an-shan Oilfield (41-03 N, 122-15 E) is part of the graben sequence that makes up the North China Basin and has spawned the Sheng-li, Ta-kang, and Shen-yang fields as well. Consequently, although we have no direct information on P'an-shan, we assume its geology is similar to that of Sheng-li and Ta-kang.

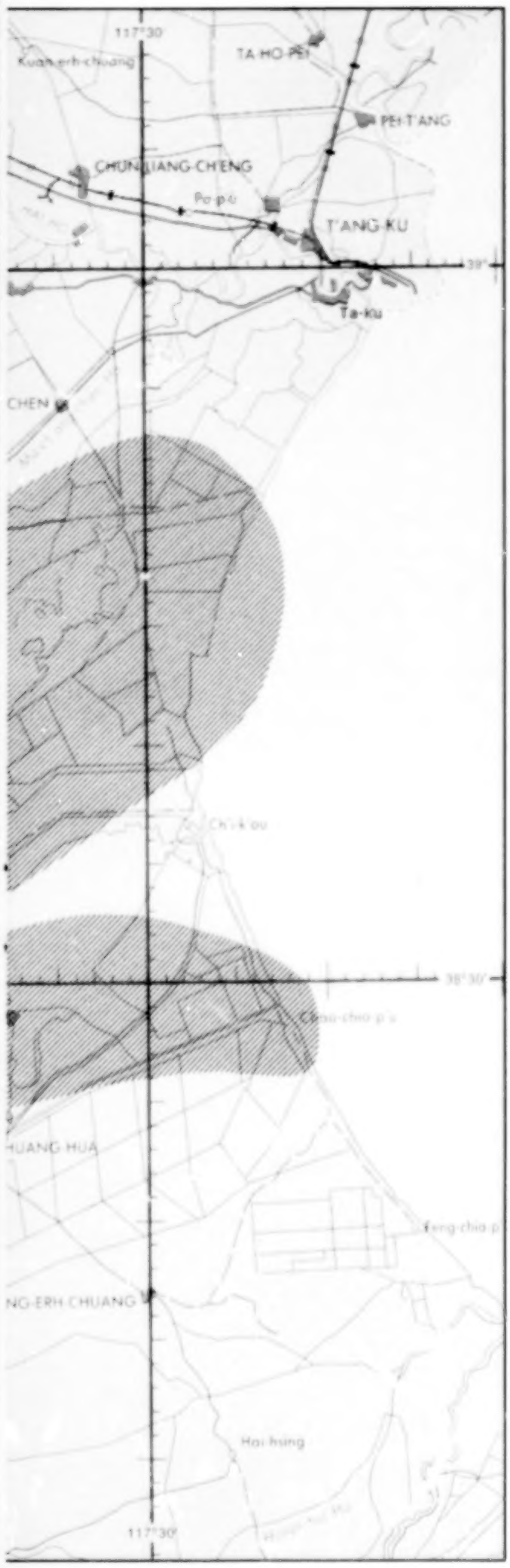
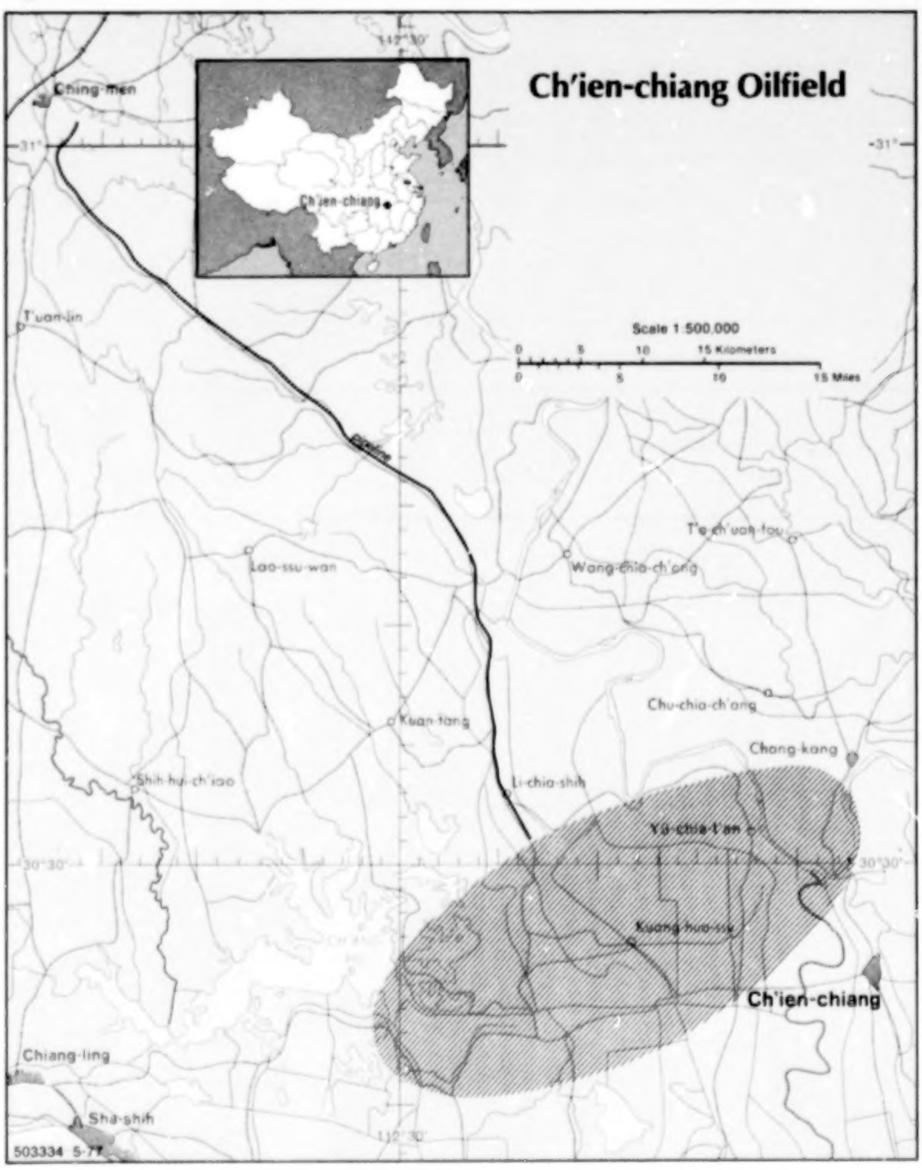


Figure 16



percent of 1975 output, was refined onsite. The main refinery, at Sa-erh-t'u, has a capacity of 84,000 b/d; the smaller units at La-ma-tien and Ching-chia-wei-tzu are of 14,000 b/d and 20,000 b/d capacity, respectively. Most of the field's

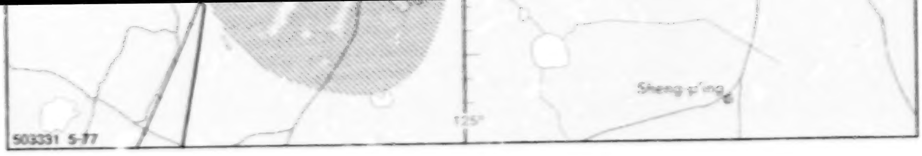
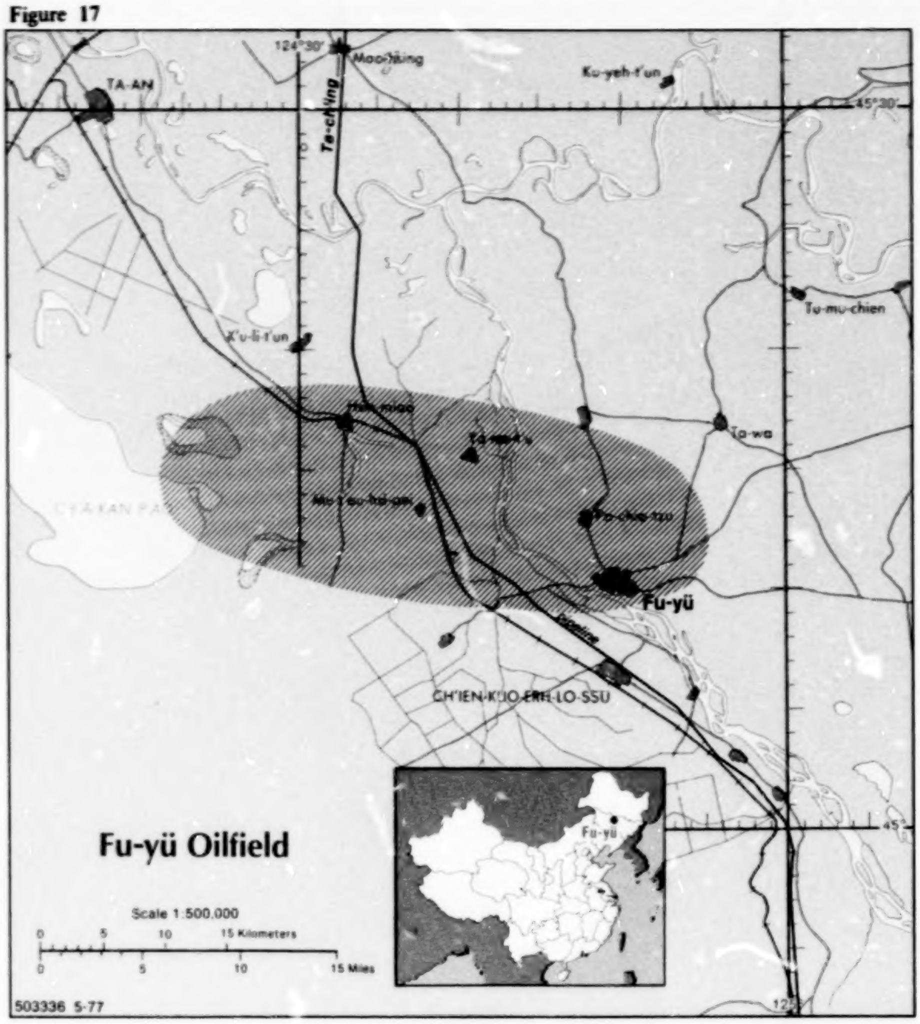


Figure 17



P'an-shan oil-bearing formations may extend southward into Po Hai; thus exploratory operations may soon begin in this part of the shallow gulf.

The field totals about 100 km^2 in the most heavily industrialized part of Manchuria. The field has a refinery and a pipeline takes P'an-shan crude directly to a refinery in the industrial center of An-shan.

Fu-yu Oilfield (45-12 N, 124-47 E)

Fu-yu is the second large oilfield (Ta-ch'ing was the first) that has been developed in the Sung-liao Basin. The other known Sung Hao Basin field at An-kuang, is still very small. Fu-yu's geology does not seem similar to Ta-ch'ing's. Extraction apparently is difficult. The total absence of publicity about the field indicates that the Chinese also suspect Fu-yu's long-term prospects are not good.

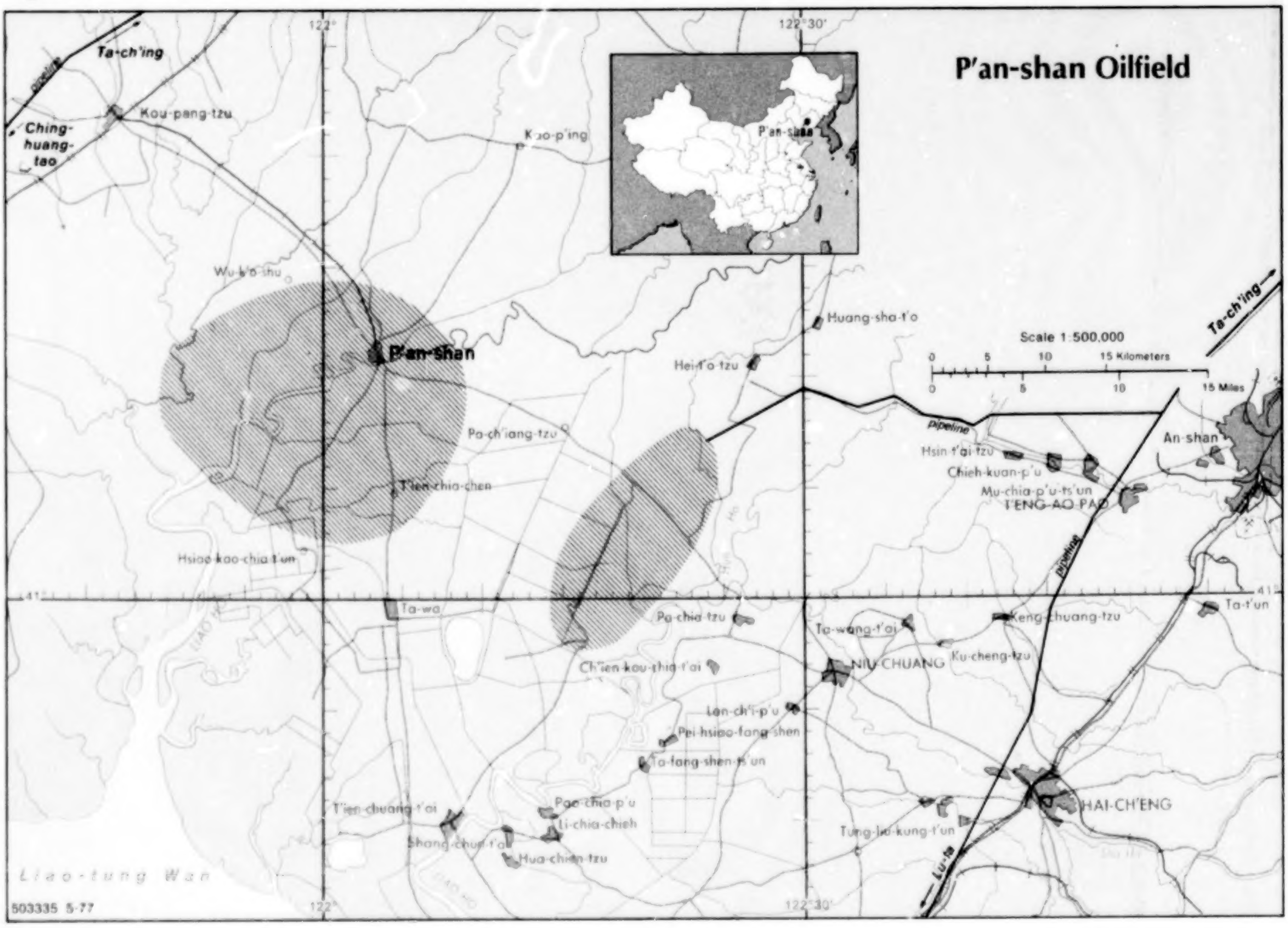
The field totals about 95 km^2 on both sides of the Sungari. It has a refinery of 40,000 b/d, and a refinery at Kirin is probably partially fed by Fu-yu. There is also a rail transfer facility.

There is no information available on the characteristics of Fu-yu crude.

The Western Oilfields

Prior to the discovery of Ta-ch'ing in 1959, the Chinese pinned their petroleum hopes on the west, where the existing

Figure 18



small fields of Yu-men and Tu-shan-tzu provided convenient starting points for exploratory efforts. Post-1949 exploration with Soviet and East European help led to the expansion of these two fields, the discovery of the K'o-la-ma-i field 130 km from Tu-shan-tzu, and prospects in the Tsaidam Basin that prompted one rhapsodic reference to a "sea of oil."

The mood in Peking nevertheless was dejected. Petroleum Vice-Minister Kang Shih-en told a conference in mid-1958 that:

> In the past, we placed our hopes on big oil fields and high production ... but we hoped against hope for eight years and nothing happened. In 1957, national oil production was only about 16,000 b/d.[21] We cannot afford to wait any more.

Ta-ch'ing's 1959 discovery, followed in a year by Sheng-li, fulfilled Kang's hopes, but left the western fields in a backwater, as skilled men and equipment were stripped away to staff and equip Ta-ch'ing. Production at Yu-men and K'o-la-ma-i declined in the early 1960s and picked up only slowly afterwards. As of 1975, all the western fields together produced less than 4 percent of national output of crude.

Some of the crude is refined and used locally or sent to Tibet. The remainder must be shipped up to 2,000 km before reaching customers of important size.

As long as reserves in the north and northeast are abundant, it does not make economic sense to invest heavily in the western fields. For long-term planning to sustain national production after the prime north and northeast reserves are depleted, Peking has the alternative of going offshore instead of or in conjunction with development of the western reserves.

Dzungarian Basin

Attempts to develop an oil industry in this 130,000 km^2 basin began in 1938-43 when Soviet engineers and geologists hired by the Sinkiang government found oil at Tu-shan-tzu. They went home after reporting that a structure at Tu-shan-tzu was promising but that the oil sands identified up to then were thin and irregular.

Exploration in the basin resumed after the Communist takeover of China, directed by the Sino-Soviet Petroleum Company, one of the joint-stock companies formed in a number of industries as vehicles for soliciting Soviet aid. The discovery of oil at nearby K'o-la-ma-i in 1955 led to a diversion of resources there when Tu-shan-tzu production was less than 1,000 b/d. K'o-la-ma-i and Tu-shan-tzu still constitute the only fields in the basin.

Tu-shan-tzu Oilfield (44-180 N, 84-15 E)

This field is in a 4 by 8 km anticlinal fold in foothill country at the northern slope of the T'ien Shan range. The fold is described by Soviet geologists as narrow and complexly folded, with a mud volcano at its nucleus, and with its oil in Tertiary sandstones. The field has grown little if at all since 1965.

The field's refinery of 30,000 b/d estimated capacity far outstrips Tu-shan-tzu's probable output of crude. Additional crude is received from K'o-la-ma-i via dual pipelines constructed between 1958 and 1960. Even so, much of the primary distiller's capacity reportedly is idle.

K'o-la-ma-i Oilfield (45-34 N, 84-53 E)

The first and second wells to strike oil at K'o-la-ma-i were drilled in 1955 and 1956, respectively. When production officially began in 1957, output probably did not exceed 1,000 b/d. Production was only 4,000 b/d in 1962, although the Chinese had estimated enough reserves to set a target of 60,000 b/d for that year. Potential may have been overestimated or the field managed badly owing to inexperience and the distorted attitudes engendered by the Great Leap Forward (1958-60), which favored immediate results at the expense of long-term recovery rates. Another problem may have been the shift of more men and equipment away from K'o-la-ma-i than originally intended.

Output peaked at about 10,000 b/d in 1965, declined to about 6,500 b/d in 1969, and then resumed a gradual rise to reach 21,300 b/d in 1975, less than 1.5 percent of national output.

The Uigur name K'o-la-ma-i, meaning "black hill," arose from the common presence of oil seeps and solid asphalt mounds. The oil deposits are in Mesozoic sandstones formed on the beds of former lakes. The sediment thickness is reported by the Soviets as 2,000-3,000 meters. Surveys during the 1950s covered 80-100 km from K'o-la-ma-i to Urho with wells drilled 2-3 km apart. The long geological period of surface seepage and evaporation has reduced the amount of oil left in the field. The Soviets reported producing strata as close to the surface and free flowing. These may have been depleted during the Leap Forward. Over the years, pumping jacks have been seen at the field. Water injection began in 1959, only four

Figure 19

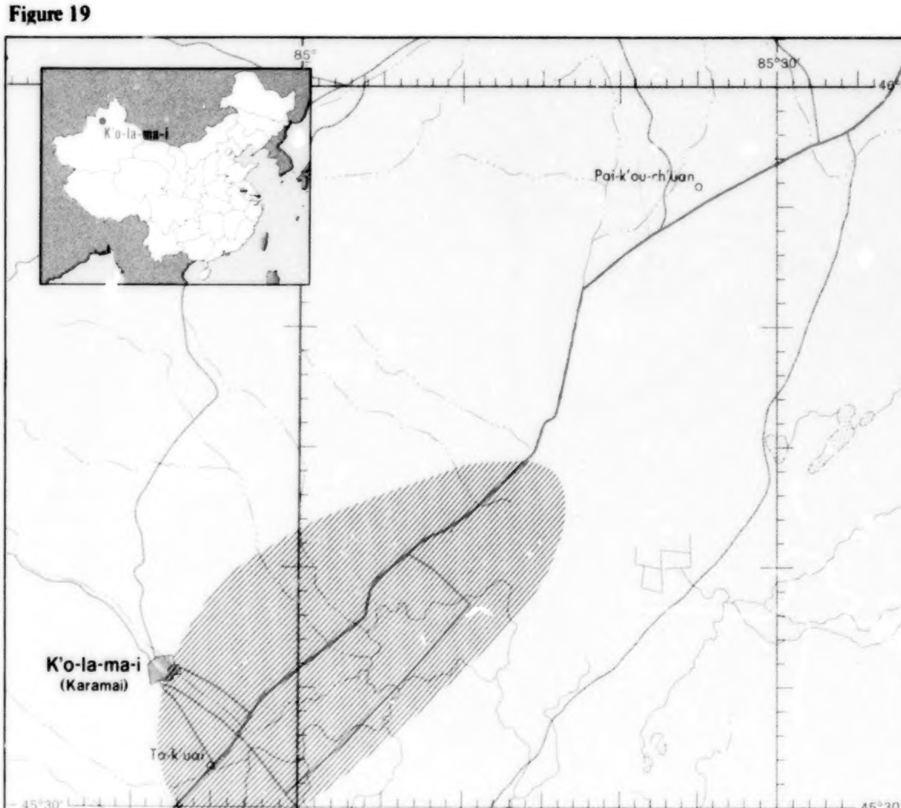
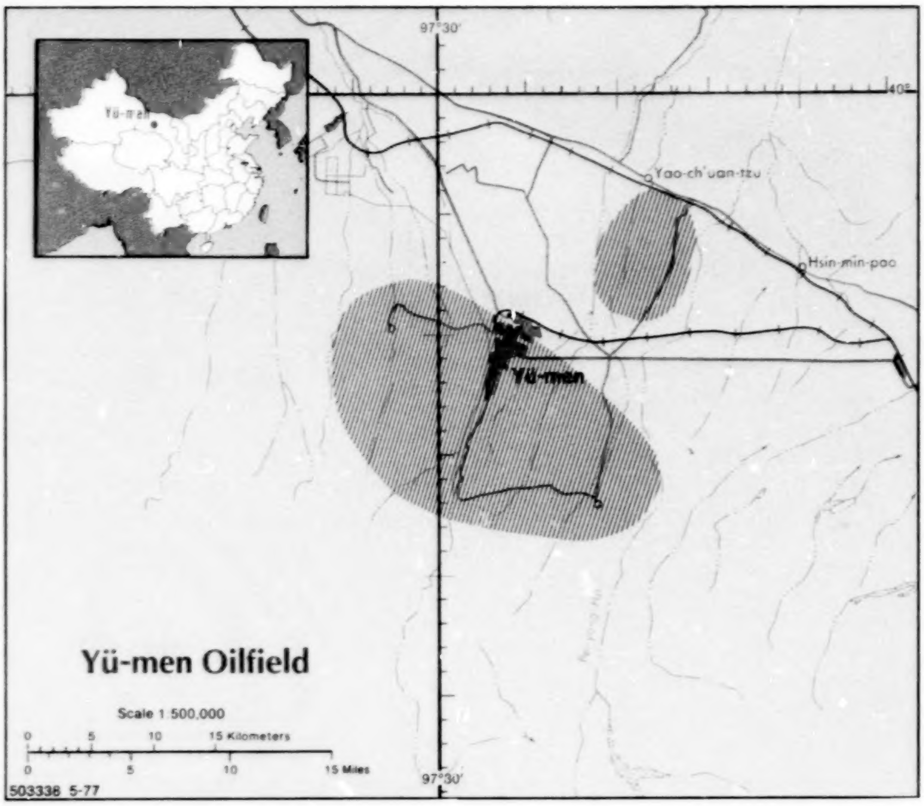


Figure 20



years after the discovery of the field.

Because of K'o-la-ma-i's remote location, about the maximum distance possible from China's main concentrations of industrial consumers, there is a possibility that the current level of production is less than that possible from the known reserves.

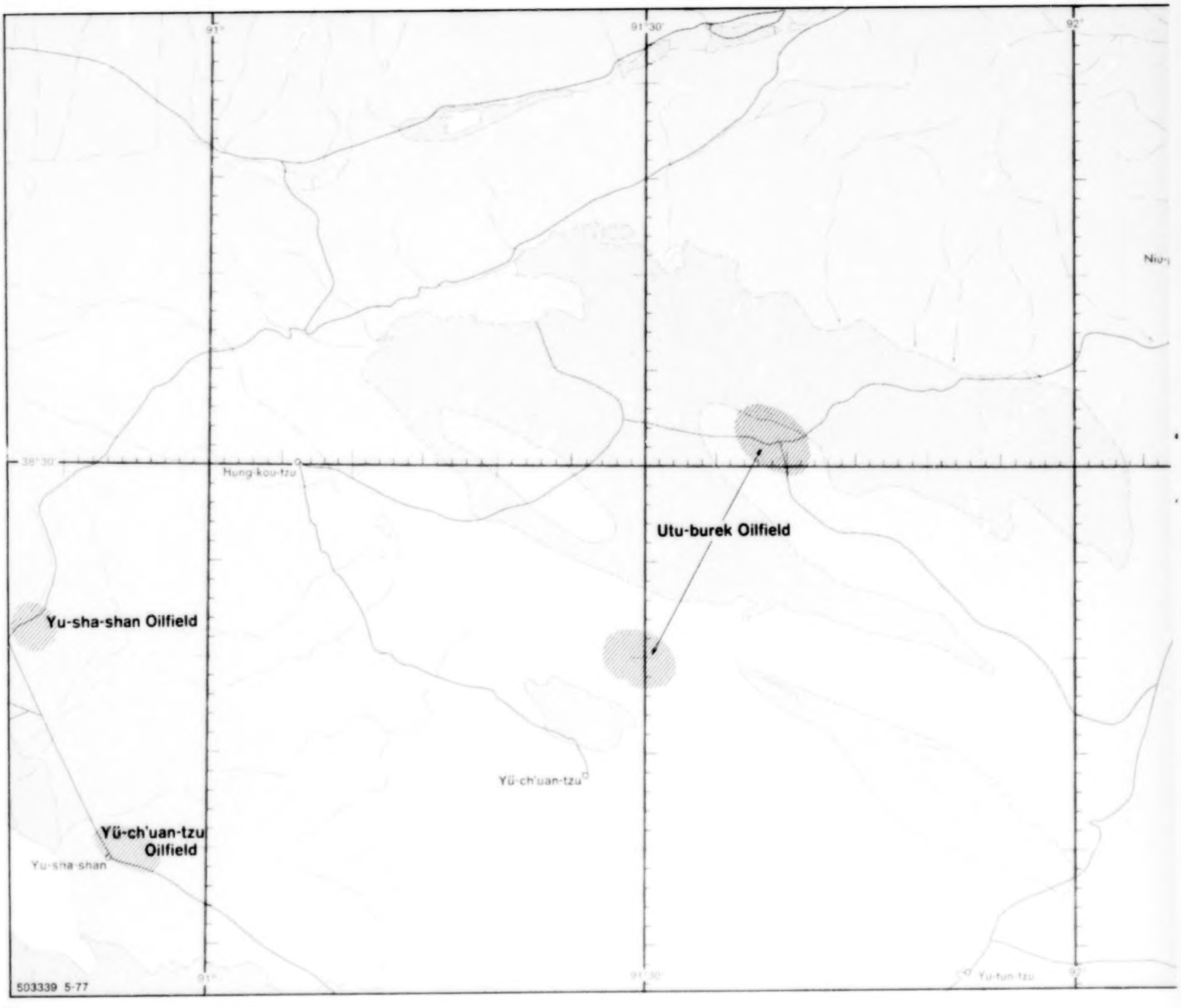
We do not have a detailed analysis of K'o-la-ma-i crude. The Soviets called it "good quality" and said it had a very low freezing point. Other sources report the crude as paraffinic with low wax and sulfur.

K'o-la-ma-i crude oil is transported out by pipeline to the Tu-shan-tzu refinery and to the railroad at Wu-lu-mu-ch'i.

Pre-Nan-shan Basin

The eminence of Yu-men (39-46 N, 97-32 E), this basin's sole field, peaked in 1957 when the Lao-chun-miao section, discovered in 1939, and the even older Shih-yu-k'ou section together accounted for about 52 percent of national production of crude. Since then, Yu-men has fallen into the background despite the opening of two new sections, at Ya-erh-

Figure 21



shih and Pai-yang-ho. The 1975 output of an estimated 15,700 b/d was about 1 percent of national output.

The original Lao-chun-mi[illegible] section is in a foothill depression reported by the Soviets as 230 km long by 20-50 km wide, north of the Nan Shan range. The oil-producing structure proper is reported as an asymmetrical anticline 25 by 8 km running in a northwest direction, with the axial part of the fold having wings of reddish Tertiary rock. The nucleus of the structure is faulted, and oil is at three levels.

Meyerhoff described the Ya-erh-shih section as consisting of Eocene through Miocene lacustrine deposits in an east-west fold along the northern side of the Nan Shan range.

With four sections in production, crude from Yu-men probably varies in characteristics. The output of the 1950s was described as high viscosity with a high paraffin content.

The total area of the four sections of Yu-men is about 72 km^2. There is one refinery of about 20,000 b/d capacity onsite. A railroad carries Yu-men crude to Lan-chou, the site of a refinery started by the Soviets and completed by the Chinese after 1960.

Tsaidam Basin

General

In the 1950s, the Chinese characterized Tsaidam as a sea of oil. Meyerhoff believes that on a per hectare basis it is the most prolific oil area in China. He reported in 1970 that 18 moderate-size, large, and giant fields had been discovered and that there were numerous surface anticlines yet to be tested. The Soviet geologist Berezina reported that as of 1958, about 100 petroleum-bearing structures had been discovered, more than 40 wells drilled, and oil found at Leng-hu, Yu-sha-shan, and Yu-ch'uan-tzu. Another Soviet geologist, Kalinov, writing in 1961, reported more than 200 flowing wells and oil strata as shallow as 240-250 meters. He said that drilling first began in 1954. Vice Minister of Petroleum Kang Shih-en referred to shallow oil-bearing strata being very common.

The encouraging reports of Tsaidam's potential notwithstanding, as of 1976 the four oilfields in the basin produced 0.8 percent of national crude output. Leng-hu, the one field of significant size, appears to be the main supplier of products for Tibet at present.

Leng-hu Oilfield (38-44 N, 93-22 E)

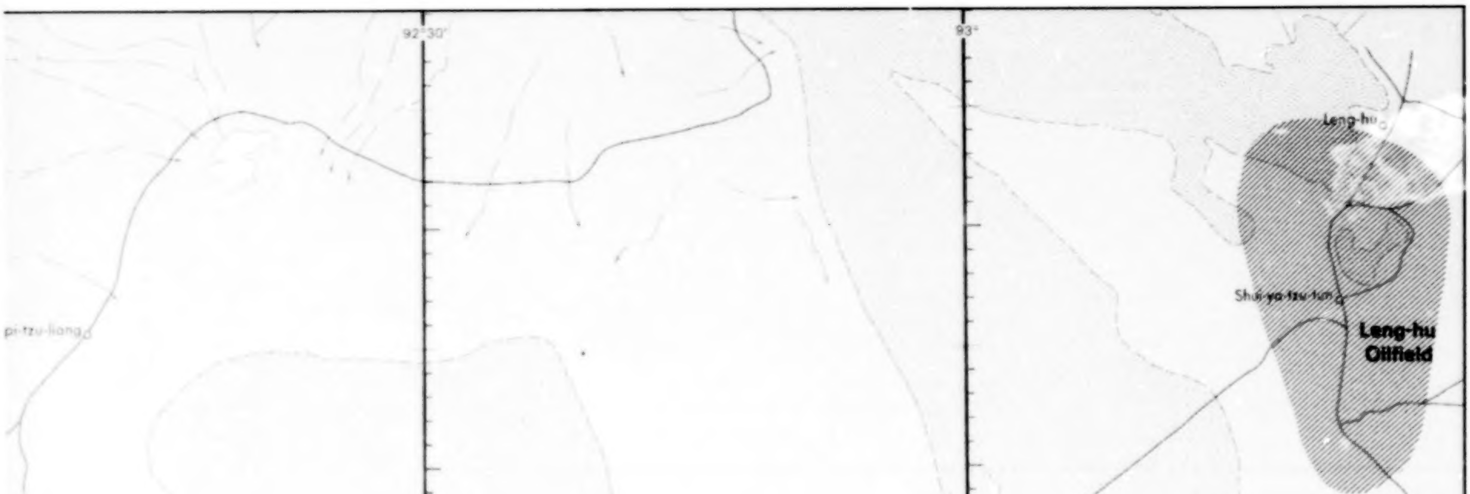
Leng-hu easily produced 95 percent of Tsaidam Basin's crude oil in 1975. Meyerhoff describes the producing structure as a complex of three closures on a single anticline producing from late Miocene and Oligocene continental sandstones. In 1970, he estimated ultimate recovery at about 1.1 BB.

The oilfield proper is in two sections totaling 70 km^2. A 6,000 b/d capacity refinery is at this field. Oil leaves by road. The crude is described as "exceeding the quality of Yu-men's petroleum."

Footnotes

20. For further discussion of China's oil transportation facilities, see Appendix C, "Chinese Port Oil-Handling Facilities," and Appendix B, "Chinese Oil Pipelines."

21. Apparently excluding shale oil.



IV. Potential Output

Figure 7 shows that of the estimated 40 billion barrels of onshore recoverable reserves, 3.7 billion barrels or 9.2 percent was produced through 1976. The remaining reserves theoretically could support the 1976 level of production for about 70 years.

In reality, the reserves will be exhausted in a much shorter time because the level of output will continue to expand if only to keep pace with domestic demand. Industry is growing and becoming more energy intensive. Rural communes are demanding more oil products for the accumulating inventory of farm machinery, particularly pumps and tractors.[22]

During the next decade, the increases in oil output will have to come predominantly from the same north and northeast regions that have supplied some 80 percent of China's oil since 1970. The Chinese record suggests that up to a decade is required to bring a large field to a high level of production. So far as is known in other regions of China exploration is in the early stages, and the development of comparatively large oilfields, with the exception of Ch'ien-chiang in Hupeh Province has not yet begun.

According to the private study of reserves, the north and northeast regions of China hold a bit less than one-half the total onshore reserves, with the Far West holding just under 40 percent and the southern basins the remainder.

If it is assumed that from 1976 on, the north and northeast regions will continue to produce about 80 percent of national output as in 1975, at a growth rate of 10 percent a year, the 50 percent probability level of their reserves will be exhausted before 1992 and the near zero level before 1996. At a 15 percent annual rate of increase, the end would come before 1989 and 1991, respectively. At 20 percent, about two thirds the rate maintained by the north and northeast over the last 15 years, the end would come before 1987 and 1989.

Thus, exhaustion of China's prime reserves—those best located and as of now the easiest to extract—could come in 20 years under favorable conditions, i.e., a rate of increase of 10 percent. During the coming five years, at least, such a rate may not meet domestic requirements, let alone provide for exports. Moreover, to provide the needs for 20 years, the reserve figure is set so high as to have virtually no chance of occurrence. At an annual rate of increase of 20 percent and with reserves set at the 50 percent probability level, the end would come in 10 years.

Technological factors could have a considerable impact on the life expectancy of Chinese reserves. Foreigners lacking detailed knowledge of Chinese capabilities in reservoir management, for example, may be assuming ultimate recovery rates that are too high.[23] In the West, to estimate ultimate recoverable reserves, the amount of oil in exploitable pools, known and estimated, is multiplied by some fraction chosen according to the estimator's assumptions about the technology available now or in the future for discovering and extracting oil and about a multitude of considerations that bear on profitability. The subjectiveness of the assumptions is the reason why reserve estimates issued by different parties, even in the United States, sometimes seem to differ by inexplicably wide margins or undergo sudden revisions upward or downward.

At present, China is technologically handicapped, compared with the Western companies that operate oil industries worldwide, and would tend to have low ultimate recovery rates. On the other hand, Chinese desire to maximize self-sufficiency in a strategic commodity may lead them to exploit reservoirs locatable with their technology beyond limits that purely commercial considerations would justify. A hint of such a tendency is given in the preface to a textbook for oil cadre which attacks the oil industries in capitalist countries for wastefully extracting "only 16-17 percent [sic]" of the oil in reservoirs because, in their quest for profit above all else, they do not develop oil and gas reservoirs rationally.[24]

The private study estimates that ultimate recovery from Chinese fields is likely to be moderately lower than anticipated for the US and most other major producing nations. This is mainly a reflection of the estimators' understanding, admittedly limited, of the geologic and reservoir characteristics of China's sedimentary basins. Meyerhoff, in an interview with Selig Harrison, stated that he used a 22 percent recovery factor; 30-33 percent is the range of ultimate recovery that US oil companies have distilled from their experience and conventionally use in their reserve calculations at home. Meyerhoff did not specify whether he was referring to his 1970 estimate of 19.6 BB or 1975 revision to 39.6 BB or both. Neither party may have compensated enough for China's technological limitations and difficult geology. The Chinese record in extraction has been too short to be of help. The old and small Yu-men Oilfield is the one case where exploitation has progressed far enough to raise the question of whether to continue; two pay strata have been declared "national reserves" apparently because they are located too deep for easy extraction.

Peking can remove the technological handicaps of its oil industry virtually overnight by changing policy to allow foreign participation. China and Brazil are the only developing countries that have built oil industries without the international oil companies.

Ideologically, the Chinese equate product-sharing—the common method to pay for foreign help—with "selling out" a nation's resources. They gleefully levy the charge against the Soviet Union and do not relish the prospect of having the tables turned. Economically, the older leaders have not forgotten what they regard as the rapaciousness of foreign firms in China prior to the Communist takeover in 1949. They seem genuinely fearful that they cannot deal on equal terms with the giant firms of today.

The obvious benefits to be had from foreign participation have kept it alive as a policy option despite its ideological bad odor. Offshore would be the favored first arena for foreign help. There, a large foreign presence would not contaminate the population at large. Offshore is where Chinese experience is the most deficient, the required equipment technologically the most taxing to build and operate, and the costs enormous. A product-sharing scheme, if it could be disguised under an alternative name, would place the entire capital and technological burden on foreign firms, yet allow Chinese engineers and workers to participate and learn.

The advocates of foreign participation had their best opportunity beginning in late 1973. China sold 20,000 b/d of oil to Japan. A mere $4.5 million were earned, but attention was attracted to the potential in selling oil to finance technology and plant imports in support of the forthcoming Fifth Five-Year Plan (1976-80). In 1974 a bigger surplus over domestic needs fortuitously coincided with the Arab oil embargo. Japan eagerly bought 80,000 b/d of crude at a premium

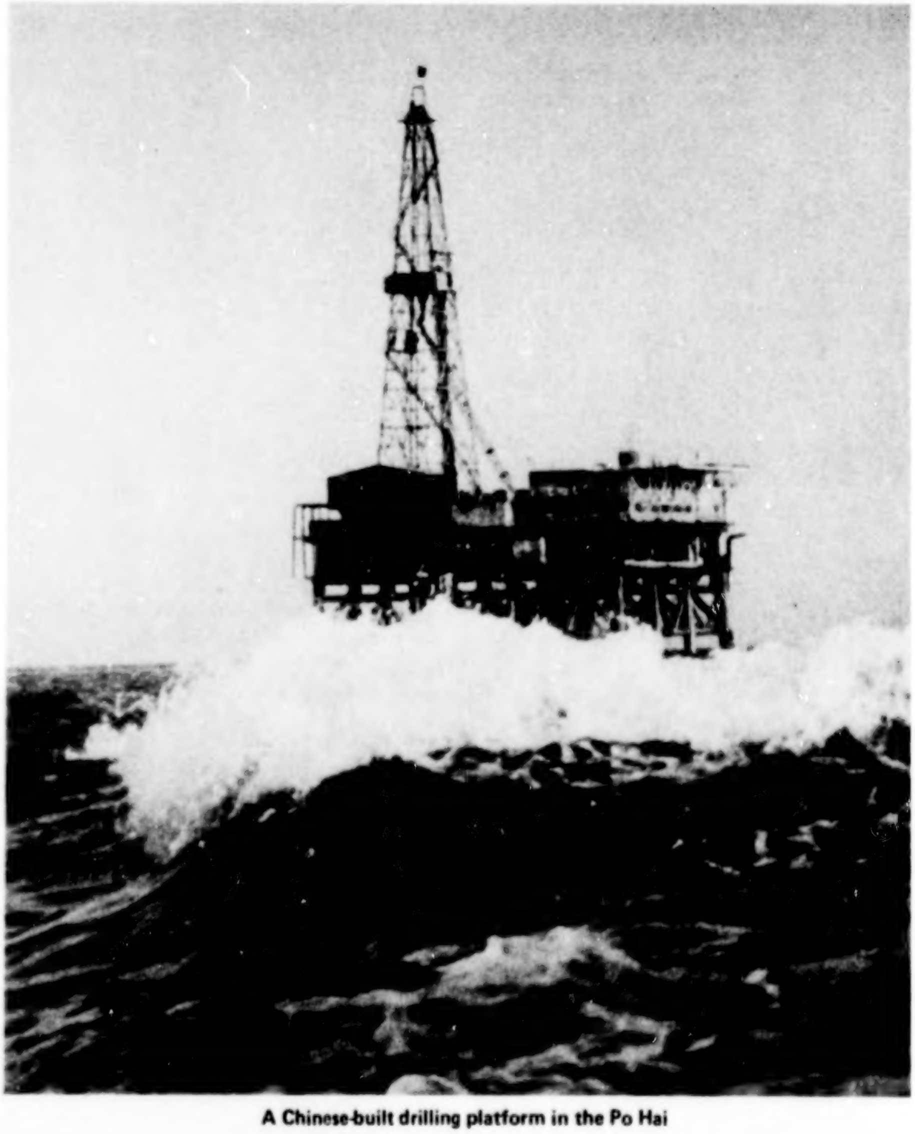
Chinese stepped up an existing program to build pipelines and port facilities. Before the bubble began to burst in the second half of 1975, Peking came to believe that exports could be expanded to 1 million b/d for Japan alone by 1980.

During most of 1975, Peking pressured the Japanese government, which in turn pressured the Japanese oil refining companies to sign a five-year contract for importing more crude oil each year to reach a 1980 target of 1 million b/d. The refineries, then caught in a recession, steadfastly refused. They cited current losses, the uncertainty of future demand for their products, the high Chinese crude prices, and the technical problems in refining Chinese crude.

The Japanese refiner's unfavorable response and the domestic anti-Teng campaign—one aspect of which was strong emphasis on self-reliance—happened simultaneously. Almost overnight, the Chinese spread a new line that China was switching priority from exports to domestic requirements and that the export target five years hence was unimportant. Only the targets for the next two or three years were said to be necessary so the Chinese oil industry could plan production. Evidently oil had been placed behind iron and steel, nonferrous metals, and coal in priority in the new five-year plan.

On several occasions during 1976, the Chinese frankly admitted that the bureaucrats associated with the policy of forced development of the oil industry to supply exports were being severely criticized for lavishing resources on an industry that as it turned out was failing to finance plant and technology imports while keeping China out of debt. As of mid-1976 the trend appeared strong to return to the traditional approach of self-reliance in developing the oil industry and orientation toward servicing domestic demand. The pre-1973 refrain was again heard from Chinese officials that China has no intention of becoming a major world oil exporter because, over the long run, production cannot be counted on to produce sizable surpluses over a growing domestic demand. Whatever chance foreign companies ever had to gain entry to China seemed to have evaporated. With the death of Mao Tse-tung in October 1976, however, the balance between officials hostile to foreign participation in developing oil resources and those willing to contemplate it is again open to conjecture.

Meanwhile, to improve its oil technology, China must continue to rely on selective purchases of equipment incorporating new capabilities. The tendency has been to buy expendables such as pipe from Japan and Europe and high-technology equipment from the United States. Through the mid-1970s, at least $50 million worth of American equipment covering every aspect of oil work from exploration to late-stage exploitation of individual reservoirs has been acquired. US oilmen do not believe this strategy by itself will do much to reduce the gap of at least 10 years between Chinese and world technological levels. Not enough samples have been bought to make a difference in current production, and the equipment in most cases cannot be easily copied. Chinese extraction rates will certainly remain low until a better route is found to tap Western technology.



A Chinese-built drilling platform in the Po Hai

Footnotes

22. For projections of domestic demand for oil, see CIA (ER) 75-75, *China: Energy Balance Projections*, Nov 75. A revision is due for publication during 1977.

23. For a discussion of ambiguities in reserve definitions, see Appendix A.

24. Staff of the Peking Petroleum Institute, *Yu Ch'i T'ien K'ai-fa yu K'ai-ts'ai (Oil and Gas: The Opening of Fields and Extraction)*, China Industrial Publishing House, Peking, 1961.

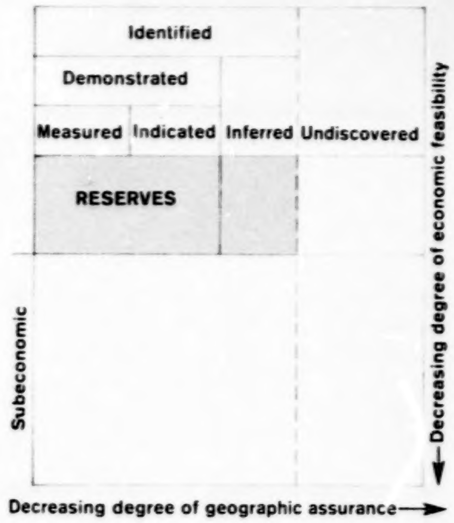
APPENDIX A

DEFINITIONS OF RESERVES

The so-called McKelvey Box, named after one of its coauthors, the Director of the US Geological Survey, is a convenient tool for organizing thinking on reserves. The entire box represents the concentrations of naturally occurring liquid hydrocarbons that are currently or potentially feasible to extract economically. In USGS parlance, the box represents the oil "resources" in the various sedimentary basins. There may be a much larger quantity of liquid hydrocarbons *in situ* not included in the box because their scattered locations or other characteristics render them unextractable.

The upper left-hand corner labeled "reserves" is the oil judged ultimately recoverable and, in fact, is what we use as our estimate of liquid oil reserves, i.e., reserves exclusive of oil shale. In the Chinese case, information is not sufficient to provide the breakdown of reserves shown in the box. Movement of the reserve section to the right depends on how successful the Chinese become in discovering oil. Downward movement depends on how the Chinese view costs as against the value of the oil they expect to extract. For estimating purposes, US oil companies usually take 30-33 percent of the box as ultimately recoverable reserves. None of the estimates of Chinese reserves is explicit on the components of the upper left-hand corner, on the distance to the right or downward, or on the percentage of the box occupied by the upper left-hand corner.

Because of their comparative technological backwardness, the Chinese, depending on the amount of foreign help they obtain, can only move slowly to the right in the box. In going down, the same backwardness would bring them to the subeconomic line sooner, but this limitation is more elastic. Because the Chinese regard oil as a strategic commodity and a key component of self-reliance, they may push downward, that is, incur more costs, than a Western oil company might judge advisable.



APPENDIX B

CHINESE OIL PIPELINES

As of mid-1976, Communist China had about 3,500 km of oil pipelines completed and about 2,000 km under construction (see Figure 1). Table B-1 lists all the pipelines along with their approximate lengths. For moving oil in bulk, China also has more than 30,000 railroad tank cars and a fleet of small coastal tankers.

Lack of information makes it necessary to estimate the capacity of Chinese pipelines by inference from the capacity of the oilfields feeding them. By this method, the large lines in the north and northeast are judged to have individual annual capacities of 20,000-24,000 b/d.

In China long-distance pipelines are 20, 25, 30, and 61 centimeters in diameter, electric welded together from 8, 10, and 12 meter sections. The 61 centimeter diameter pipe is imported from Japan; Chinese-made pipe more than 30 centimeters in diameter is spiral formed and cannot withstand high pressures. Since Peking claims some 200,000 t of pipe used in the northeast from 1970-73 was domestically produced, at least 1,126 km—the equivalent of 200,000 t—of pipelines in that region should be 30 centimeters or smaller in diameter. Pipe imports from Japan during 1970-73 totaled 133,000 t. All Japanese pipe sales to China, beginning with 1968 and running through 1975, add up to 328,000 t.

The 20-61 centimeter "first class" pipelines are wrapped in six alternating layers of plastic cloth and bitumen. The lines are then buried.

Chinese pipelines divide geographically into four groups:

(1) *North and Northeast.* There are about 3,700 km of pipelines completed or under construction in the north and northeast. They serve industrial and urban consumers and coastal-traffic and export harbors.

(2) *Far West.* The dual K'o-la-mai-i-Tu-shan-tzu line conveys part of Ko-la-ma-i's crude output to the Tu-shan-tzu Refinery. The K'o-la-ma-i-Wu-lu-mu-ch'i line is K'o-la-ma-i's primary outlet to the railroad at Wu-lu-mu-ch'i.

(3) *Tsinghai-Tibet.* A 1,100 km pipeline from Ko-erh-mu through rugged mountains and severe-weather terrain to La-sa is under construction. This line is difficult to justify on purely economic grounds. Tibet's normal oil requirement is a few hundred thousand tons a year. The pipeline, even if substantially less than the largest size built in China, will have a capacity of millions of tons. The line probably is being built primarily for strategic purposes: to guarantee oil supplies for any military operation that might be triggered by the unsettled border dispute with India.

(4) *South China.* The pipeline from the Ch'ien-chiang Oilfield to its captive refinery at Ching-men is technically in north China because it is north of the Ch'ang Chiang. Nevertheless, the bulk of Ch'ien-chiang's output is distributed in the southern provinces. The line from the Sheng-li Oilfield to Nan-ching also is southern in purpose if not in location. It supplements the coastal tankers which are bringing Ta-ch'ing and Sheng-li oil from Lu-ta, Ch'in-huang-tao, and Huang-tao harbors to Shanghai-Nan-ching for processing and distribution up the Ch'ang Chiang valley.

Construction of pipelines predated the beginning of the Chinese crude oil export program in the last quarter of 1973. The prospect of high earnings from exports led to an acceleration of the pipeline—and port—construction program.

Nonetheless, the overall Chinese pipeline program is domestically oriented. The T'ieh-ling Lu-ta, T'ieh-ling Ch'in-huang-tao, and Sheng-li Huang-tao lines are well located to play a role in exports, but they and each of the other lines could be justified on the basis of domestic functions alone.

The Chinese appear to have mastered the basics in pipeline laying. Lines have been built quickly despite mountains, rivers, harsh weather, and manpower and equipment deficiencies. We do not have information on the day-to-day operations of Chinese pipelines, but there has been no evidence of serious operational problems, although operational costs are high.

The Chinese have imported some pipeline laying equipment including US mechanized systems. Talks involving other advanced technology items such as gas turbines to be used as pumps so far have not resulted in sales.

Table B-1

Oil Pipelines

	Length (Kilometers)
Complete	
Ta-ch'ing-T'ieh-ling, western line	500
T'ieh-ling-Ch'in-huang-tao	400
T'ieh-ling-An-shan	200
K'o-la-ma-i-Tu-shan-tzu (dual)	300
Ching-men-Ch'ien-chiang	100
K'o-la-ma-i-Wu-lu-mu-ch'i	300
Ta-ch'ing-T'ieh-ling, eastern line	500
Lin-i-Chi-nan	100
Sheng-li-Huang-tao	200
T'ieh-ling-Lu-ta	500
P'an-shan-Chin-hsi	100
Ch'in-huang-tao-Fang-shan	300
Total	**3,500**
Under construction	
Ta-kang-Fang-shan	300
Lin-i-Nan-ching	400
Lin-i-Po-hsing	100
Ko-erh-mu-La-sa	1,100
Sheng-li-Hsin-tien (dual)	100
Total	**2,000**

APPENDIX C

CHINESE PORT OIL-HANDLING FACILITIES

Communist China requires oil-handling capability at ports in order to load and unload domestic coastal tankers, load tankers for the oil export trade, and unload tankers bringing crude from Africa, the Middle East, and Albania. The six ports engaged in bulk oil handling have developed a high degree of specialization.

Three of the ports—old Lu-ta, Ch'in-huang-tao, and Huang-tao—load small tankers for shipment to Shanghai. Lu-ta and Ch'in-huang-tao are fed by pipeline from Ta-ch'ing, and Huang-tao is fed by pipeline from Sheng-li. Each of these ports has also loaded oil onto small tankers for export since late 1973. Their inability to handle supertankers has been a significant cost disadvantage for Chinese crude in the world market. Chinese coastal tankers do not go beyond Taiwan to south China even though deliveries to Canton, for example, would provide a more direct route to the oil-deficit deep south than shipments through Shanghai.

Oil facilities at Lu-ta's old harbor were expanded from early 1973 through August 1974; four oil piers were built and more storage capacity was created a short distance from the port. The maximum size tanker that can be accommodated, however, is still only 30,000 DWT.

Ch'in-huang-tao, the second small-tanker port, is directly east of Peking. One of the pipelines from Ta-ch'ing Oilfield reached Ch'in-huang-tao by mid-1973. Based on the size of ships seen at the pier, it is believed Ch'in-huang-tao can accommodate 50,000 t tankers.

Huang-tao, the third small-tanker port, is on the southern side of the Shantung Peninsula, on an island opposite the port of Ch'ing-tao. Sheng-li oil arrives by pipeline and continues offshore by means of a short submerged pipeline to a cargo ship converted into a storage and loading facility. Huang-tao can handle tankers up to 70,000 t. The storage facilities onshore total about 110,000 t.

China's only large-tanker port is new Lu-ta, a deepwater anchorage 13 km northeast of the old Lu-ta port. Development for oil handling began in October 1974 when prospects for exports were still strong. The objective was to overcome the cost disadvantage of having to ship crude in small tankers. The development of the new port, called Nien-yu Bay by the Chinese was completed in October 1976, by which time facilities were capable of handling tankers of up to 100,000 t in capacity. Tankers that size barely qualify for supertanker status by international standards so the Chinese disadvantage in transport costs is only partially canceled out by new Lu-ta port.

The oil-handling facilities at Chan-chiang port are used exclusively to unload crude oil from Africa, the Middle East, and Albania. During the past three years, 20,000-26,000 b/d has been brought in. The crude is transshipped from Chan-chiang by rail and by pipeline to the refinery at Mao-ming.

A deepwater wharf with two piers completed in 1974 accommodates 70,000 t tankers though it was built to handle 50,000 tonners.

APPENDIX D

CHINESE CRUDE OIL PRODUCTION VS. REFINING CAPACITY

A check on the acceptability of the national crude oil output estimates can be made by comparing them with the estimates of refining capacity (see Table D-1).

The percentage utilization figures are reasonable. The relatively low rates for the earlier years are attributable to inefficiencies in transportation preventing optimum matching of crude supply with refining capacity and of frequent shutdowns due to low design and maintenance standards. During 1967-68 the economic disruptions caused by the Cultural Revolution depressed the rates of utilization to all-time lows. The high rates for recent years reflect the very tight capacity situation. In 1974 and 1975, Peking seriously considered proposals to have Chinese crude refined abroad.

Table D-1

Chinese Refining Capacity and Capacity Utilization

	National Crude Output	Crude Net Imports	Crude Consumed at Powerplants	Crude Requiring Refining [1]	Average Refining Capacity [2]	Utilization of Capacity
	Million Metric Tons					*Percent*
1965	11.0	0.1		10.5	13.6	78
1966	14.1	0.1		13.5	17.8	76
1967	13.9	0.1		13.3	20.0	66
1968	15.2	0.1		14.5	22.8	64
1969	20.4	0.1	−1	18.5	26.0	71
1970	28.2	0.5	−1	26.4	31.5	84
1971	36.7	0.2	−2	33.2	38.0	87
1972	43.1	0.1	−3	38.2	45.6	84
1973	54.8	−0.2	−4	48.0	54.4	88
1974	65.8	−3.5	−5	54.3	58.7	93
1975	74.3	−7.7	−6	57.7	66.5	87

[1] After a 5% transport and refining loss.
[2] The arithmetic average of yearend figures.

This field is in a 4 by 8 km anticlinal fold in foothill country at the northern

APPENDIX E

DERIVATIONS OF CHINESE CRUDE OIL OUTPUT ESTIMATES

Table E-1
National Estimates [1]

		1949	1961	1962	1963	1964	1965	1966	1969	1970	1971	1972	1973	1974	1975
1961	Reported														
	Estimate	42.5308													
1962	Reported		1.1080[2]												
	Estimate	47.1241	1.1080												
1963	Reported			1.1070[3]											
	Estimate	52.1664	1.2266	1.1070											
1964	Reported														
	Estimate	70.9712	1.6687	1.5060	1.3605										
1965	Reported														
	Estimate	89.8968	2.1137	1.9077	1.7233	1.2667									
1966	Reported						1.2840[4]								
	Estimate	115.4275	2.7140	2.4494	2.2127	1.6264	1.2840								
1969	Reported						1.8800[5]								
	Estimate	167.1247	3.9295	3.5465	3.2037	2.3548	1.8591	1.4479							
1970	Reported						2.5000[6]		1.4090[7]						
	Estimate	231.3771	5.4402	4.9100	4.4351	3.2602	2.5738	2.0045	1.3845						
1971	Reported	301.0000[8]			5.7700[9]					1.2860[10]					
	Estimate	301.0000	7.0772	6.3874	5.7700	4.2412	3.3483	2.6077	1.8011	1.3009					
1972	Reported						4.0000[11]		2.1000[12]		1.1600[13]				
	Estimate	353.2072	8.3047	7.4953	6.7708	4.9768	3.9290	3.0600	2.1134	1.5265	1.1734				
1973	Reported														
	Estimate	449.4840	10.5684	9.5383	8.6164	6.3333	5.0000	3.8941	2.6895	1.9426	1.4933	1.2736			
1974	Reported					7.6000[14]	6.0000[15]						1.2000[16]		
	Estimate	539.3808	12.6821	11.4460	10.3396	7.6000	6.0000	4.6729	3.2274	2.3312	1.7920	1.5271	1.2000		
1975	Reported						6.8000[17]								
	Estimate	609.0626	14.3205	12.9247	11.6754	8.5818	6.7751	5.2766	3.6444	2.6323	2.0235	1.7244	1.3550	1.1292	
1976	Reported						7.6000[18]						1.3000		1.1300
	Estimate	658.7236	16.1230	14.5514	13.1449	9.6620	7.6297	5.9407	4.1031	2.9637	2.2782	1.9414	1.5256	1.2713	1.1259

[1] The base for the national crude oil output series is a claim of 36.7 mt. or 734,000 b/d (data are presented in barrels per day and in metric tons because the Chinese report all data in tons) for 1971 made by Chinese officials to Ichizo Kimura, Director of the Japan International Trade Promotion Association, as reported in *Mainichi Shimbun*, 22 Dec 73.

Output for 1949–59 are official claims. The years 1949–58 are given in *Ten Great Years*, Peking, 1960. The 1959 claim is in *Jen-min Jih-pao*, 23 Jan 60.

The years 1967-68 have been estimated by assuming rates of growth compatible with the general trends in an economy disrupted by the Great Proletarian Cultural Revolution. The Chinese have never released data covering crude oil output in those two years.

The remainder of the years through 1976 were derived by a computer program using a method of least squares to spread evenly the errors assumed to be in Chinese percentage claims because of rounding, unannounced revisions of earlier versions of the same claim, unstated changes in definitions of categories, and other causes.

[2] *FBIS*, 26 Mar 63, G-4. Output in 1962 increased 10.8% over 1961.

[3] *China News Service*, 6 Nov 63. First half of 1963 increased 10.7% over the same period of 1962. We have extended the rate to the entire year.

[4] NCNA, Peking, 26 Sep 66. The statement that output for the first eight months increased 28.4% over 1965 was extended to the entire year.

[5] *China's Foreign Trade*, 1975, p. 6. Output in 1969 increased 88% over 1965.

[6] *Peking Review*, 10 Dec 71, p. 16. Output in 1970 increased 150% over 1965.

[7] *FBIS*, 27 Sep 72, B-9. Output in 1970 increased 40.9% over 1969.

[8] *Peking Review*, No. 39, 29 Sep 72, p. 12. Output in 1971 increased by more than 300-fold over 1949.

[9] *Jen-min Jih-pao*, 27 Sep 72, or *SCMP* 72-4, 10-13 Oct 72, p. 124. Output during 1963-71 increased at a 24.5% average annual rate of growth.

[10] *K'o-hsueh Shih-yen* (Scientific Research), No. 5, May 72. Output in 1971 increased 28.6% over 1970.

[11] NCNA, Peking, 31 Aug 73. Output during 1965-72 increased an average of 22% a year.

[12] *FBIS*, 5 Sep 73, B-10. The average annual rate of growth during 1969-72 was 28%.

[13] *BBC*, FE/W/706/A/7, 10 Jan 73. Output in 1972 increased 16% over 1971.

[14] *Peking Review*, No. 41, 1975. Output during 1964-74 increased 660%.

[15] *FBIS*, 3 Jan 75, B-10. Output in 1974 was more than six times 1965.

[16] NCNA, Peking, 2 Jan 75. Output in 1974 increased 20% over 1973.

[17] *Ta-kung Pao*, Hong Kong, 30 Jun 76, p. 1. Output in 1975 increased 5.8-fold over 1965.

[18] *FBIS*, 6 Jan 77, E-19. Output in 1976 was 13% more than 1975 or 7.6 times 1965.

Sheng-li Estimates

This series is calculated using 1973 as the base. Peking claims that output during 1964-73 was 16.8 times the output attained in the 42 years before liberation. Output during 1907-49 was 2.78 mt, according to an article by Chiang Ta-yu and Chu Pao-lin in *Jan-liao Hsueh-pao* (Acta Focalia Sinica), Vol. 4, No. 4, 1959, p. 263-281, translated in JPRS, No. 5642, 13 Oct 60. Therefore, 2.78 x 16.8 = 46.704. Furthermore, if the area of a right triangle is 46.7 and the base is 10, then the height representing 1973 output is 46.704 = 0.5 (10) h; h = 9.34, rounded to 9.5 (see Bobby Williams, in *China: A Reassessment of the Economy*, "The Chinese Petroleum Industry, Growth and Prospects," JEC, 94th Congress, 10 Jul 1975).

1974–Output in 1974 increased 16 percent over 1973 (*FBIS*, 7 Jan 75, G-10).

1965–Output in 1974 was some 15 times 1965 (*FBIS*, 7 Jan 75, G-10). Also, 1974 was some 15 times 1965 (*FBIS*, 7 Jan 75, G-10). Also 1973 was 13 times 1965 (*China Reconstructs*, Oct 74).

1975–Output in 1975 increased 34 percent over 1974 (*FBIS*, 23 Dec 75, G-8). Output in 1975 increased 33 percent over 1974 (*FBIS*, 27 Apr 76, G-8). We have taken the later claim as the more definitive.

1962–The first well of the oilfield went into production in September producing 500 t a day. Since only one quarter of the year remained, there were 91.25 days of production.

1964–A well of 1,134 t output a day was drilled. The well from 1962 produced 500 t a day. The new well produced 1,134 t a day. Annual output of the two wells was thus 596,410 t. This should be regarded as a minimum figure.

1966–A Chinese source reports that the 1966 goal was 2 mt and that it was achieved.

1970-72–The same source reports that the goals for 1970 and 1971 were 4.5 mt and 6.5 mt, respectively, although he did not claim that they were necessarily fulfilled. He says that 8.45 mt for 1972 is a quite accurate figure determined at a yearend review meeting held at the oilfield.

Table E-2

Ta-ch'ing Estimates[1]

Ta-ch'ing Crude Oil		1960	1963	1965	1966	1970	1971	1972	1973	1974
1963	Reported									
	Estimate	5.5932								
1965	Reported									
	Estimate	8.9769	1.6050							
1966	Reported			1.2660[2]						
	Estimate	11.0877	1.9823	1.2351						
1970	Reported			2.5000[3]						
	Estimate	22.3185	3.9903	2.4862	2.0129					
1971	Reported	27.5900[4]	5.0000[5]			1.2600[6]				
	Estimate	27.9662	5.0000	3.1153	2.5223	1.2531				
1972	Reported			3.6000[7]			1.1450[8]			
	Estimate	32.2790	5.7711	3.5958	2.9112	1.4463	1.1542			
1973	Reported			4.0000[9]				1.1000[10]		
	Estimate	35.7505	6.3917	3.9862	3.2243	1.6018	1.2783	1.1075		
1974	Reported	43.8300[11]							1.2200[12]	
	Estimate	43.7227	7.8170	4.8706	3.9433	1.9590	1.5634	1.3545	1.2230	
1975	Reported	51.1900[13]		5.5000[14]	4.6800[15]					
	Estimate	50.6253	9.0512	5.6395	4.565?	2.2683	1.8102	1.5684	1.4161	1.1579
1976	Reported			6.0000[16]						
	Estimate	54.4425	9.7336	6.0647	4.9102	2.4393	1.9467	1.6866	1.5228	1.2452

[1] The base for the Ta-ch'ing crude oil output series is a statement by the Chief of the Ta-ch'ing Revolutionary Committee to visitors that output in 1972 was 70,000 t a day.

[2] *China Reconstructs*, Jan 67, p. 7. Output in the first nine months of 1966 increased 26.6% over the same period of 1965.

[3] *Peking Review*, 10 Dec 71, p. 16. Output in 1970 was 2.5 times 1965.

[4] *FBIS*, 4 Jan 73, B-7. During the 11-year period 1960-71, the average annual rate of growth was 35.2%.

[5] *FBIS*, 4 Jan 73, B-8. Output in 1971 was more than five times 1963

[6] *FBIS*, 12 Apr 72, B-7. Output in 1971 increased 26% over 1970.

[7] NCNA, Peking, 25 Aug 73. Output in 1972 increased 260% over 1975.

[8] *SCMP-73-18*, 30 Apr-4 May 73, p. 213. Output in 1972 increased 14.5% over 1971.

[9] *FBIS*, 29 Mar 74, A-3. Output in 1973 was four times 1965.

[10] *BBC*, FE/W757/A/5, 9 Jan 74. Output in 1973 increased 10% over 1972.

[11] *FBIS*.,29 Mar 74, A-3. Nyerere was told during a visit to Ta-ch'ing that in the past 14 years, output rose at an average of 31% a year.

[12] *FBIS*, 26 Dec 74, K-3. Output in 1974 increased 22% over 1973.

[13] The Chinese told visitors that over the 15 years from 1960, output at Ta-ch'ing increased at an average 30% a year.

[14] *FBIS*, 23 Dec 75, L-3. Output in 1975 was 5.5 times 1965.

[15] BBC, FE/W870/A/12, 24 Mar 76. Since 1966, the average annual rate of growth has been 18.7%.

[16] *FBIS*, 6 Jan 77, E-19. Output in 1976 increased 8.7% over 1975. Compared with 1965, output increased fivefold. Text misprinted 1967 for 1965 and probably confused 1976 equals sixfold 1965 with 1976 increased sixfold over 1965.

Ta-kang Estimates

This series is calculated using 1973 as the base. *China Reconstructs* Oct 74, p. 8, reported that output at Ta-kang "over the last eight years" was 3.1 times the total for the whole of China in the 42 years of 1908-49. Output during 1907-49 was 2.78 mt, according to an article by Chang Ta-yu and Chu Pao-lin in *Jan-liao Hsueh-pao* (Acta Focalia Sinica), Vol 4. No. 4, 1959, pp. 263-281. Therefore, 2.78 x 3.1 = 8.62. We use 6 years as the period of production at Ta-kang because rapid growth began in 1967. If the area of a right triangle is 8.62 and the base representing the number of years is 6, then the height representing 1973 output was 8.62 = 0.5 (6) h; h = 2.87, rounded to 3. (See Bobby Williams, *China: A Reassessment of the Economy*, "The Chinese Petroleum Industry, Growth and Prospects," JEC, 94th Congress, 10 Jul 75.)

1967–The average annual rate of growth during 1967-73 was 60.9 percent (*China Reconstructs*, Oct 74, p. 8).

1974–Output in 1974 increased 24.7 percent over 1973 (*FBIS*, 2 Jan 75, k-3).

1975–Output in 1975 increased 16 percent over 1974 (*Ta Kung Pao* Hong Kong, 6 Jan 76).

1970–Output in 1975 was 4.5 times 1970 (*Ta Kung Pao*, Hong Kong, 16 Jan 76).

1971–Output in 1970 increased 100 percent over 1969 (*FBIS*, 29 Mar 74, k-1).

Yu-men, K'o-la-ma-i, and Tsaidam Estimates

These three series are from Bobby Williams, *China: A Reassessment of the Economy*, "The Chinese Petroleum Industry, Growth and Prospects," JEC, 74th Congress, 10 Jul 75).

The missing years in the original series have been filled in by linear interpolation.

Values for 1975 were obtained by linear regression of the years dating back to the last rising trend for each oilfield.